THE UNIVERSITY OF ALBERTA

AN ANALYSIS OF FARM MANAGEMENT FACTORS IN RELATION TO FARM PROFITS

by

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies and Research a thesis entitled "An Analysis of Farm Management Factors in Relation to Farm Profits," submitted by Lawrence Edward Hurd in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

This study is concerned with the usefulness of comparing efficiency factors from a farm operator's business records with group averages for similar farmers. Commonly called "comparative analysis," this approach has traditionally been used in various North American farm accounting programs. In Canada, one of the more recent of these programs is the Canadian Farm Management Data System called Canfarm, which is being used by some Canadian farmers. Although still in a developmental stage under the direction of the Canada Department of Agriculture, the Canfarm system is intended to provide tools to assist Canadian farmers in management decisions. One of its several objectives is a comparative analysis program whereby the individual farmer can compare his business to averages of other similar enterprises.

In order to examine the usefulness of comparative analysis, a study of some farm management factors used in farm business analysis programs in Alberta was conducted using regression and correlation analysis. The usefulness of grouped farm data comparisons was evaluated. Prediction equations for estimating the operator's return to labour and management were also sought.

The 354 farm records obtained from the Economics Division, Alberta Department of Agriculture were stratified in two ways. The first approach involved grouping the sample farms according to their predominant enterprise. The second stratification grouped farms by

soil zone without regard for types of enterprise within each zone.

Results of the study indicated that a number of traditional farm management efficiency factors are of no value to the farm decision maker and may, in fact, be misleading. This is demonstrated by the large body of analysis that yielded inconclusive and contradictory results. The importance of many other factors was doubtful. Moreover, it is difficult to integrate the few important factors with relevant economic theory.

The failure of most farm management factors to be consistently related to farm profits is attributed to extreme data variability. This variability is the result of differing methods of asset evaluation among farms; heterogeneous resources, production processes, and weather conditions; and accounting errors in physical inventory and financial data. These factors are reflected in the operator's labour earning residual, which was used as the success indicator. The importance of stratification and the need to compare similar farms is thus apparent. Accounting accuracy is also very important; however, many important aspects of accounting rest on the farmer's judgement, and even a sophisticated program such as Canfarm cannot eliminate these errors.

The selected regression equations were poor predictors of the operator's return to labour and management on the same farms stratified according to enterprise. In general, higher multiple coefficients of determination (R^2) were obtained from similar prediction equations applied to the soil zone groups, but considerable

variation existed from one group to the next. High correlations among explanatory variables and the problem of multicollinearity prevented the derivation of highly predictive equations.

It was concluded that comparative analysis in its present form is an incomplete analysis tool, that tends to minimize the usefulness of economic theory in management decisions. Comparative analysis can, however, play a role in indicating major adjustments required in the business. More experimentation is required in heterogeneity problems and farm stratification methods, accuracy of measurement, and application of relevant economic theory to farm accounts in order to improve the utility of comparative analysis. It is suggested that the modern farm entrepreneur could improve his decision making by relying more on reasoning through economic models than on questionable comparisons with his neighbours using comparative analysis alone.

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CHAPTER I

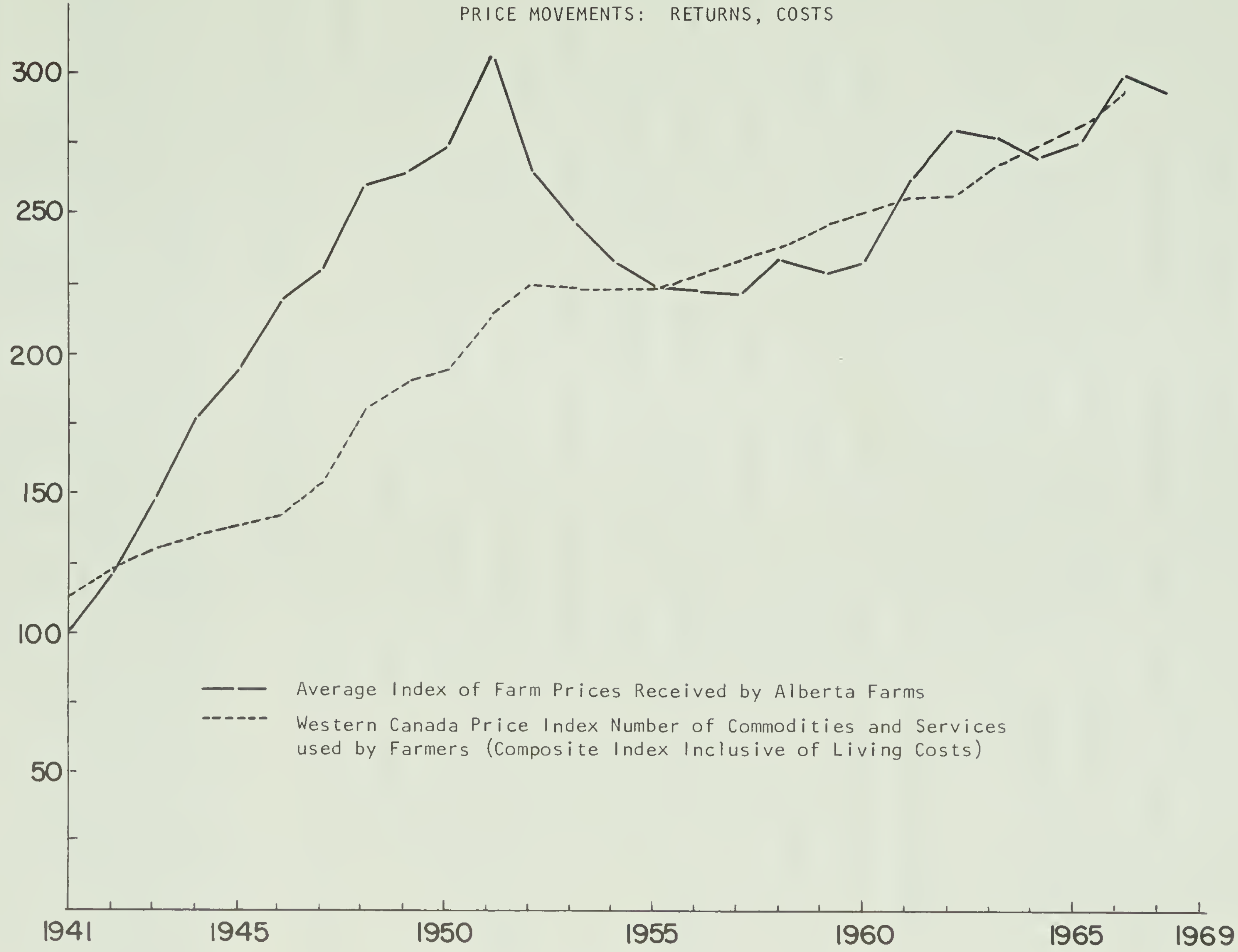
INTRODUCTION

Canadian agriculture has experienced vast improvements since the early homestead days when a farmer could make what was considered an adequate living on 160 acres of land. The technological revolution of the past several decades has resulted in a Canadian agriculture with excess capacity. Due to the efforts of researchers, extension personnel, and promoters from private companies, there has been a marked increase in the use of such items as feed supplements, herbicides, insecticides, and labour saving equipment. These trends have been accompanied by improved livestock and crop varieties.

This technological revolution in agriculture has contributed, in part, to making the Canadian standard of living and diet among the best in the world. The real income of the farmer has not, however, kept pace with that of others in the national economy. There are several reasons for this problem. Because the average farmer cannot influence the price which he receives for his product, overproduction by the total industry from new technology results in lower prices to the farmer. Also, the farmer cannot affect the price which he pays for inputs such as machinery. The overall situation has resulted in unstable incomes with steadily rising costs of production, as illustrated in Figure 1. Thus the need has arisen for larger, better managed units.

Figure 1

PRICE MOVEMENTS: RETURNS, COSTS



Source: Alberta Department of Agriculture, <u>A Historical Series of Agricultural Statistics for Alberta</u>, Publication No. 850 (Edmonton: ADA, 1969).

The cost-price squeeze resulting from farm mechanization and other new technologies has forced Alberta farmers to operate their farm units more as businesses than as just a way of life. It has also resulted in a reduction of the number of census farms[1] in Alberta and in an increase in the number of commercial farms.[2] Table 1 illustrates the trend to larger farms. Commercial farms[3] increased from 45,203 in 1961 to 48,971 in 1966.

Advancing technology has dictated that the farm manager must keep the farm business in constant change for the operation to maintain or improve the standard of living of the farm operator and his family. It has been considered essential that the farm operator keep a satisfactory record or bookkeeping system to assist him in making sound management decisions. Records can provide valuable information about the past performance of the farm and individual enterprises. By using the budgeting technique (complete or partial), the farm manager has a powerful tool at his disposal for making decisions about the allocation of scarce resources to achieve given ends. To be of any value farm records must be analyzed, interpreted, and used in decision making.

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[1]For census purposes a farm is defined as a holding on which agricultural operations are carried out and which is three acres or more in size, and with an agricultural production in 1955 valued at $250.00. For census purposes in 1961 and 1966, a farm refers to an agricultural holding of one acre or more in size with sales of agricultural products during the twelve months preceding the census date of $50.00 or more.

[2]Census farms having sales of $2,500.00 or more during the preceding year are described as commercial farms.

[3]Canada Dominion Bureau of Statistics, Canada Year Book (Ottawa: Queen's Printer, 1968).

Table 1

CENSUS STATISTICS OF AGRICULTURE FOR ALBERTA

		1941	1951	1961	1966
Farm Population	No.	383,964	345,222	287,814	281,583
Number of Farms	No.	93,200	84,315	73,212	69,411
Average Size	Ac.	434	527	645	706
Farm Classification					
under 3 acres	%	-	.2	.3	.5
3 - 9		-	1.4	.9	1.1
10 - 69		-	2.4	2.5	3.3
70 - 239		-	28.1	21.1	18.2
240 - 399		-	29.2	26.5	23.7
400 - 559		-	14.3	16.1	15.8
560 - 759		-	9.1	11.5	12.5
760 - 1119		-	7.6	10.2	11.9
1120 - 1599		-	3.9	5.4	6.4
1600 - 2239		-	1.8	2.5	3.0
2240 - 2879		-	.7	1.0	1.3
2880 & over		-	1.3	2.0	2.3
Farm Capitalization					
Land & Buildings	$	490,826	1,015.389	1,715,367	2,865,472
Machinery & Equipment		116,128	390,003	550,876	785,032
Livestock & Poultry		104,066	384,324	451,254	565,116

Source: Alberta Department of Agriculture, *Statistics of Agriculture Alberta, 1968 and 1969*, Publication No. 853-6 (Edmonton: ADA, 1971).

In Alberta use of the Prairie Provinces Farm Account Book has been recommended to farmers by the Alberta Department of Agriculture This book has been revised several times since its introduction with the aim of making it more useful as one tool in the decision making process on the farm.

The Economics Division, Alberta Department of Agriculture conducts a voluntary farm business analysis program for the farmer. The cost to each participating farmer was ten dollars in 1967.[1] This fee was increased to twenty-five dollars in 1970. Approximately five hundred commercial farms cooperated in the 1967 program. Farmers furnished the basic physical and financial data from their farm records at workshops held throughout the province. Local district agriculturists and regional farm economists assisted in gathering the required data from the individual farm account books. The data was analyzed by the Farm Management Branch, Economics Division, Alberta Department of Agriculture with the aid of a computer. Records of the individual farmers are confidential, but group averages on income, expenses, and productivity and efficiency measures are calculated and published. The individual farmer can then compare his business to the averages for the group to locate strong and weak points in the organization and operation of his business. This is commonly called "comparative analysis."

Each province presently has its own system of record

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[1] Bruce Hackett, Head of Farm Management Branch, Alberta Department of Agriculture, Interview, Edmonton, Alberta, July, 1971.

analysis. Essentially the same farm management factors are calculated, but some differences exist in the method of calculation. With the stated objective of eliminating duplication of effort and to create comparability of results from analysis, a computerized Canadian Farm Management Data System called Canfarm is presently under development and use. It is intended to assist farmers in keeping and analyzing their records to improve their management practices and their incomes. It will also be a source of data for research purposes. Comparative analysis has been stated as a goal of the Canfarm system, and an appraisal of its usefulness in farm management decisions is, therefore, crucial.

Problem

Considerable experience and sound judgement are required to interpret the results of the farm business analysis from the many factors which are calculated. One objective of the interpretation is to isolate the weak and strong factors on the individual farm by comparing them with the average of the group (comparative analysis). Because numerous factors are calculated, there is a possibility that some or all of the factors are not significantly correlated to the operator's return to labour and management. Eliminating those management factor calculations which are of no value and perhaps adding more useful ones will assist the farmer and the extension worker in interpreting the results of the farm record analysis.

Objectives

There are two main objectives for this study. The first is to identify and evaluate the various efficiency factors affecting the operator's return to labour and management which are calculated by the Alberta Department of Agriculture. In this way the usefulness of grouped farm data (comparative analysis data) can be evaluated.

The second objective is to determine ways of predicting the magnitude of the operator's labour earnings from easily available efficiency factor data.

Hypothesis

It is hypothesized that the farm operator's return to labour and management is a function of the various factors measuring the following:

1. Size of business
2. Labour use
3. Equipment use
4. Capital use
5. Crop productivity
6. Livestock productivity

A few examples of such factors are total farm acres, labour as a percentage of total expenses, equipment investment per cultivated acre, variable costs as a percentage of total costs, gross returns from crops, and gross returns from livestock respectively.

In order to utilize conventional tests of statistical significance, the hypothesis is usually stated in the form of the

null hypothesis. This hypothesis states that the farm operator's return to labour and management is not a function of the various farm management factors which are calculated by the farm business analysis program in Alberta. Rejection of the null hypothesis indicates acceptance of the alternative hypothesis, which states that the measure of profit is a function of the calculated farm management factors.

Data

The data for this study were obtained from the Economics Division, Alberta Department of Agriculture. They represent the farm account records of the 354 farms on the Alberta Farm Business Analysis program in Alberta for the year 1967.

Methodology

The statistical tool called correlation and regression analysis was used to relate the various farm management factors to farm profit.

CHAPTER II

LITERATURE REVIEW

A review of writings and past research indicates that the calculation of farm management factors and comparative analysis have been used for many years. The marked increase in the number of factors used in comparative analysis has added to the difficulty of isolating strong and weak parts of the farm organization. The general approach has been to divide the factors into groups so that all factors measuring a particular aspect of the farm business (e.g., livestock efficiency) can be compared to the group averages.

Black et al.,[1] for example, divided the factors into five categories as follows:

1. Size of farm business
2. Balance and diversity of enterprises
3. Index of crop yields
4. Returns per $100 of feed fed to livestock
5. Miscellaneous list of efficiency factors

Hopkins and Heady[2] have classified farm management factors into the following groups measuring nine different characteristics of the farm enterprise:

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[1]John D. Black et al., Farm Management (New York: The Macmillan Company, 1947), Chapter 22.

[2]John A. Hopkins and Earl O. Heady, Farm Records and Accounting, 5th ed. (Ames, Iowa; Iowa State College Press, 1962), Chapter 13.

1. Size of business
2. Efficiency in the cropping system
3. Livestock efficiency
4. Labour efficiency
5. Machinery economy
6. Cost ratios
7. Capital ratios
8. Income ratios
9. Enterprise selection.

Several studies have been made in the past sixty years relating various factors to measures of farm profit. Only those studies carried out in the United States and Canada will be discussed in succeeding paragraphs of this chapter. These date back to 1913 when G. F. Warren[1] found that labour income, net profit per acre, and efficiency in the use of horses, machinery, and labour increased as the size of the farm (measured in acres) increased.

Numerous studies on economies of size have revealed that average costs decrease and returns increase as the size of the farm increases. Expansion of the farm output can be in terms of size (additional acres or livestock) or in terms of increasing the proportion of variable capital to fixed capital (more intenstive). Expansion is also frequently characterized by additional capital relative to labour. From a study in the United States by Tweeten[2]

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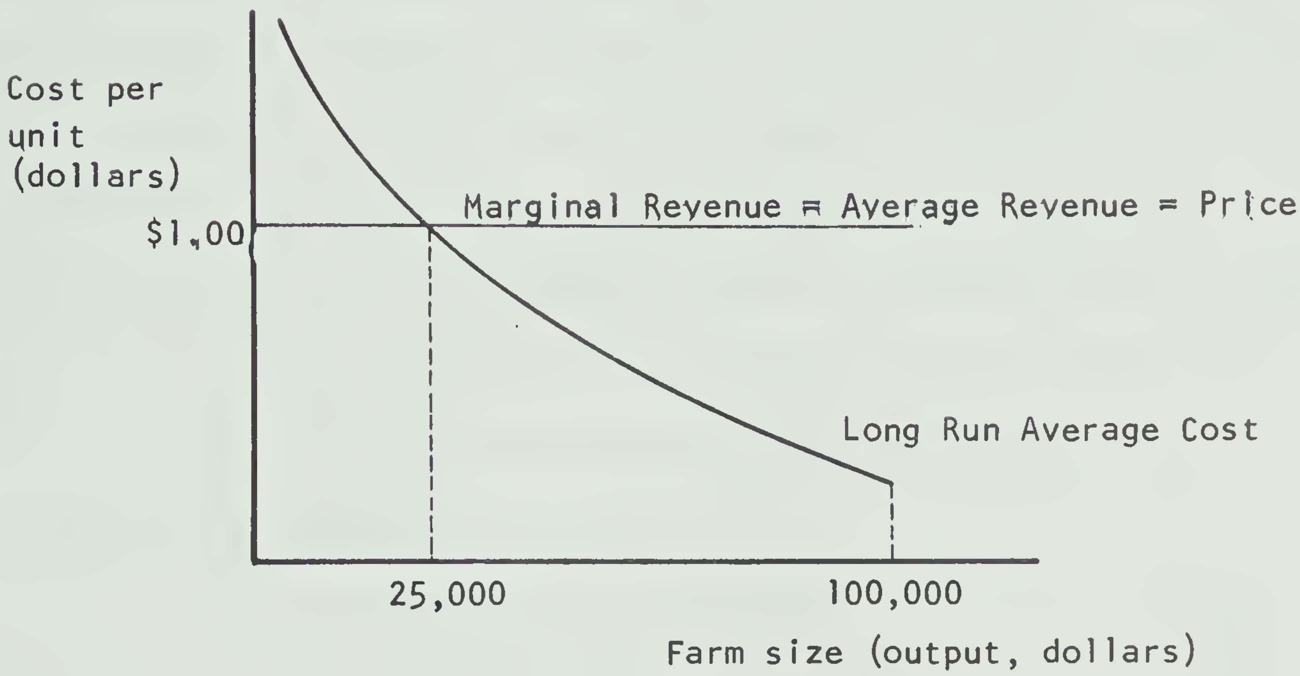
[1] G. L. Warren, Farm Management (New York: The Macmillan Company, 1917), Chapter 17.

[2] Luther G. Tweeten, "Theories Explaining the Persistence of Low Resource Returns in a Growing Farm Economy," American Journal of Agricultural Economics, Vol. 51, No. 4 (1969), pp. 798-817.

in 1960, the following long run average cost curve was plotted.

Figure 2

LONG RUN UNIT COST OF PRODUCTION



Source: Luther G. Tweeten, "Theories Explaining the Persistence of Low Resource Returns in a Growing Farm Economy," American Journal of Agricultural Economics, Vol. 51, No. 4 (1969), p. 810.

Farms with sales under $25,000 on the average lost money because all production costs were not covered in 1960. Farms with sales greater than $25,000 received a return per unit of output equal to the difference between the average revenue and the average cost. Additional studies on economies of size have been summarized

by the United States Department of Agriculture.[1]

Between 1930 and 1950 research on the factors affecting farm profit was done by Hopkins, Mosher and Case, Schrumpf, Robertson, Thibodeaux *et al*., Wright, Czarowitz and Bonnen, Misner, and Kyle. Their results have been summarized by John A. Speicher.[2] Indiana farm records for the years 1930-1934 and 1946-1950 were analyzed by Kyle. Multiple correlation analysis showed that 66 percent of the variation in net farm income was explained by the following variables: tillable acres, crop yield index, productive man-work units per man, percentage tillable acres in corn, and feed fed per tillable acre. The following simple correlations were obtained with net farm income as the dependent variable:

1.	Total capital investment	(.66)
2.	Tillable acres	(.56)
3.	Number of sows	(.45)
4.	Total pigs weaned	(.44)
5.	Productive man-work units	(.37)

From 599 Indiana farm records for the year 1950, Kyle found that capital investment was the best measure of size for the farms studied. Productive man-work units appeared to be the poorest measure of size. Kyle's results do not agree with those of Misner,[3]

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[1] United States Department of Agriculture, Economic Research Service, *Economies of Size in Farming*, Agriculture Economic Report No. 107 (Washington, D.C.: USDA, February 1967).

[2] John Albert Speicher, "Relationship of Dairy Farm Net Income to Specified Farm Management Factors" (unpublished Ph.D. thesis, Michigan State University, 1964).

[3] E. G. Misner, "Thirty Years of Farming in Tompkins County, New York," in Speicher, *op. cit.*, p. 9.

who reported in 1927 that from seven measures of size, productive man-work units produced a larger change in labour income than any other measure.

Castle and Becker[1] point out that acres of land may be an accurate measure of size in an area where the land is homogeneous and the type of farming is similar. Acreage loses its value as a measure of size, however, when comparing farms of different types within an area because of the varying intensity of land use. If crops are the main source of income, then acres is a good measure of size.

Peterson and Bauer[2] have claimed that productive man-work units provide a much superior measure of size to acres alone, especially on mixed farms where a farm small in acres can still be a very large business because of a large livestock enterprise or an extensive crop.

Wilkes[3] used 1952 data from 124 south central Michigan farms. Using labour income as the measure of profit and dependent variable, the following simple correlations in order of importance were calculated:

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[1] Emery N. Castle and Manning H. Becker, Farm Business Management, (New York: The Macmillan Company, 1962), p. 104.

[2] T. A. Petersen and L. Bauer, Alberta Farm Business Report, 1962 (Edmonton: Alberta Department of Agriculture, 1963), p. 16.

[3] P. Wilkes, Association of Farm Business Measures with Farm Incomes, Quarterly Bulletin 38:533 (East Lansing, Michigan: Michigan Agricultural Experiment Station, 1956).

1. Income per $100 expense (.74)
2. Livestock income per tillable acre (.18)
3. Productive man-work units per man (.16)
4. Dairy sales per cow (.15)
5. Crop yield index (.08)
6. Tillable acres per animal unit (.00)

Albright[1] studied the management factors influencing the percent return on capital investment for 39 Los Angeles County commerical dairy farms for the period 1956-1960. As pointed out by Speicher[2] in his review of this research, the most important management factor according to the study was production cost on a per cow basis. The influence of feed costs was significant in three out of the five years studied. The price received for butterfat and the pounds of butterfat produced contributed significantly to the percent return on capital investment in four of five years. The cost of herd replacements and operating costs were significant in only two of the five years. Cows per man, hours per cow, percent cows dry, milk produced per cow, culling rate, investment per cow, feed efficiency, number of cows per herd, prices paid for hay and concentrate, and interest on assets contributed very little to the percent return on investment.

Bryant[3] carried out a cross-sectional regional analysis

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[1] J. L. Albright, Analysis of Land, Capital, Labor, and Management in Large Commercial Dairy Herds in Los Angeles County, 16th International Dairy Congress, Section 9:2, 1962.

[2] Op. cit.

[3] Wilfred K. Bryant, "Causes of Inter-County Variations in Farm Earnings," Journal of Farm Economics, Vol 48, No. 3, Part 1 (August 1966).

of inter-county variations in farmers' earnings in 1960. He found that the level of education influenced farm earnings in some areas but not others. A relative prevalence of functional illiteracy (greater than 25 years old with zero to six years of education), a relative lack of nonfarm employment opportunities for farm residents, and a low average value of land and buildings per farm in a county all resulted in low earnings and income levels. The remoteness of the community from industrial-urban concentrations was an important cause of low income and earnings level east of the Mississippi. This relationship did not hold west of the Mississippi.

Wilson[1] studied the persistence of differences in the incidence of low income farms in Illinois. He found by regression analysis (linear model) that the average acre size of farm (inverse relationship), the soil productivity rating, the number of tractors per 1000 acres of cropland (inverse relationship), the percentage of total farm operators working 100 days or more off farms, and the number of rural farm persons under 15 and over 65 years of age per 100 persons from 15 to 65 years of age in the rural farm population made a significant contribution to the percentage of low income farms. Only the percentage of all employed persons 14 years of age and older engaged in agriculture and the percentage of total rural farm population 25 years of age and over with elementary schooling were not significantly related to the percentage of low

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[1] Walter L. Wilson, "Factors Associated with the Incidence of Low Income Farms in Illinois Areas" (unpublished Ph.D. thesis, University of Illinois, 1959).

income farms. The combination of all these factors explained 91 percent of the variation in the percentage of low income farms.

In 1960 Holmsen[1] studied the variability of income and the factors affecting income on commercial dairy farms. The factors studied were size of business, labour efficiency, crop yields, milk production per cow, and milk price. He found that the variability of labour income increased when the size of business, labour efficiency, and milk production per cow increased. When crop yields increased, up to a certain level variability in labour income increased. Size of business was the factor with the greatest variability.

A multiple regression model was used by Speicher[2] to study the relationship of dairy farm net income to thirty-eight selected farm management factors. The factors used measured size, crop efficiency, livestock efficiency, labour efficiency, costs, intensity, and organization. One thousand and forty-one Michigan dairy farm record years (1958-1962 inclusive) were used. The thirty-eight management factors were grouped according to specified characteristics. The numbers of factors within each group were reduced by accepting only those which made a significant contribution to

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[1] Andreas A. Holmsen, "Variability in Income and in Factors Affecting Income on Commercial Dairy Farms in the North Country and Central Plains Regions of New York State" (unpublished Ph.D. thesis, Cornell University, 1960).

[2] *Op. cit.*

the explained variation in net income. The following fourteen management factors were accepted in the prediction equation:

1. Number of cows
2. Tillable acres
3. Crop value per tillable acre
4. Soil value rating
5. Percentage cash crops
6. Machinery expense per tillable acre
7. Percentage rented land
8. Tillable acres per cow
9. Milk sold per man
10. Milk sold per cow
11. Milk price per hundredweight
12. Percentage base milk
13. Dairy cattle income per cow
14. Livestock income per $100 feed expense

The above fourteen independent variables, in a linear functional relationship, explained 75 percent of the variation in the dependent variable, net income. Net income did not increase proportionately to increases in size; thus a curvilinear relationship existed. Measures of crop efficiency (crop value per tillable acre, soil value rating, and percent cash crops) were also curvilinear. Net income increased at a decreasing rate as the crop efficiency factors increased. Livestock efficiency factors were linear for those measuring output and curvilinear for those measuring price. Labour efficiency factors were found to be linear. Tillable acres, crop value per tillable acre, machiner expense per tillable acre, and livestock income per $100 feed expense accounted for 61.5 percent of the variation in net income.

This study has two weaknesses. The first is the use of net income as the measure of profit. Heady[1] makes the following comment about net farm income:

> Pioneer production economists soon found that net farm income served unsatisfactorily as an index of resource or production efficiency, since (1) one farm uses unpaid family labor, while another pays a wage for hired labor, (2) tenants share farm income with the landlord, while the owner-operator receives the full amount, (3) interest is a debit in the accounts of the farm with borrowed capital, and (4) reflections of efficiency may be obscured on small farms because of a small volume of output.

The second weakness is the apparent existence of multicollinearity[2] among the many independent variables used in the final prediction equation. The author acknowledges the existence of multicollinearity, but does not appear to have dealt with the problem completely. Milk sold per cow and dairy cattle income per cow, for example, should be very closely related.

Pearse[3] used (1) the farm records of the University of Missouri mail-in record program for dairy farms, 1961 to 1964 inclusive, (2) the analysis of farms which participated in the program for three out of the four above years, and (3) the analysis of 237 farms for 1964. Factor and regression analyses were applied

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[1] Earl O. Heady, Economics of Agriculture Production and Resource Use (Englewood Cliffs, New Jersey: Prentice-Hall, 1952), p. 404.

[2] Multicollinearity is the name given to the problem which arises when some or all of the explanatory variables in a relation are so highly correlated one with another that it becomes difficult to disentangle their separate influences and obtain a reasonably precise estimate of their relative effect.

[3] Robert A. Pearse, A Study of Relationships Used in Farm Record Analysis (University of Missouri, College of Agriculture, 1966) pp. 1-76.

to the 1964 data to determine if it were necessary to use different analyses for different types of farms. In addition to searching for relatively few variables which could be used to predict farm income, another important objective was to ascertain the importance of the variables in explaining the measures of profit; namely, operator's labour and management return and percent return to capital. For analysis purposes the farms were placed into five groups: dairy, grain, grain-livestock or livestock, general (which included poultry and mixed livestock), and all 237 farms.

Factor analysis is a statistical tool not often used by agricultural economists. The analysis consists of grouping variables according to a specified number of factors. Variables of a similar nature are associated with the same factor. The factor analysis used by Pearse showed that many variables were associated with one factor. If these variables were substituted for each other in the regression analysis, a slightly lower R^2 was obtained, but the variable still made a significant contribution to the measure of profit. This indicated that a reduction in the number of variables calculated in farm business analysis programs was possible.

In his conclusions Pearse points out that misleading results could result from applying factor analysis to farms diverse in nature. Similar results were found using factor analysis and multiple regression analysis. Some of the variables that Pearse singles out as being significantly related to the measures of profit are fertilizer cost per crop acre, seed and supplies per crop acre,

number of beef cows, labour cost per farm, productive man-work units on crops, and fixed and variable machinery costs per $100 of production. It is noted that corn yield is significant for all types except grain-livestock. This was an unexpected result because corn is an important enterprise on this type of farm.

Major studies in Canada and Alberta related to the problem outlined in Chapter One are almost non-existent. Bauer[1] did a regression analysis on 55 central Alberta farms in 1961. The following factors were used in a linear regression model with labour earnings as the measure of profit and dependent variable:

1.	Productive man-work units	(.41)
2.	Total annual equipment costs per man	(.02)
3.	Equipment costs per cultivated acre	(.03)
4.	Capital turnover in years	(.12)
5.	Crop yield index	(.04)
6.	Diversity index.	(.03)
	Total or R^2 =	(.65)

The percentage of variation in labour earnings explained by each factor is shown in parentheses. The six factors listed above explained 65 percent of the variation in labour earnings. The largest contribution was made by size, measured in productive man-work units. All factors except variable costs as a percentage of

[1] L. Bauer, "Labour Earnings on 55 Central Alberta Farms in 1961" (unpublished study, Alberta Department of Agriculture, 1961).

total costs, productive man-work units per man equivalent, and livestock yield index made a significant contribution to labour earnings. Some of the results were not consistent with the economic theory outlined in Chapter Three. Labour earnings, for example, decreased when variable costs as a percentage of total costs increased. Other unexpected results included labour efficiency and equipment costs per man. Labour earnings increased when the labour efficiency (productive man-work units per man equivalent) decreased. Profits increased when total annual equipment costs per man increased.

Kehoe[1] did a similar study on fifty beef feeder operations enrolled in the 1968 Alberta Farm Business Management Program. These farms were located primarily in the black and thin black soil zones. Return to management and risk was used as the dependent variable with the following independent variables:

1.	Capital use (gross returns per dollar of fixed costs)	(.38)
2.	Labour hours (hours per hundredweight produced)	(.16)
3.	Feed conversion (hundredweight feed per hundredweight beef produced)	(.19)
4.	Gross return per hundredweight produced	(.06)
5.	Feed cost per hundredweight of ration	(.07)
	Total or R^2 =	(.86)

All factors made a significant contribution and when combined, explained 86 percent of the variation in the measure of profit.

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[1] F. X. Kehoe, <u>1968 Beef Feeder Enterprise Analysis</u>. Publication No. 821-422 (Edmonton: Alberta Department of Agriculture, 1970), p. 15.

Labour was valued at $300 per month for the calculation of return to management and risk. The correlation between feed conversion and feed cost was .46, and the correlation of feed conversion and gross return per hundredweight produced was .39. Profits increased when labour hours (hours per hundredweight produced), feed conversion (hundredweight feed per hundredweight beef produced), and feed costs decreased. Profits increased when gross returns per dollar of feed cost and gross returns per hundredweight produced also increased.

The results of the studies to date show considerable variation and in some cases are conflicting. Most of the projects have been confined to specified areas of the United States with the results depending on the area and type of farming. Regression analysis has been the statistical tool most commonly used. Various measures of profit are used as the dependent variable in a linear model with some (e.g., net farm income) having definite disadvantages. (The use of residual profit measures and their problems will be dealt with at greater length in Chapter Five.) There is also the problem of closely related factors being used in the same regression equation, which can create large problems of interpretation (multicollinearity).

It is evident that researchers have recognized the overall problem involved in comparative analysis, but the search for an answer has not resulted in any concrete universal conclusions. There is also an apparent lack of relating farm management factors to

economic theory. Because no major studies have been carried out in Canada and more specifically in Alberta, there is justification for study and evaluation of farm management factors obtained from the records of Alberta farmers.

CHAPTER III

THEORETICAL FRAMEWORK

General

<u>Farming Objectives</u>

In general, the objective of a farmer is to maximize satisfaction. As pointed out by Hobbs and Warrack,[1] "it is generally concluded that human behaviour is goal-oriented." Although usually the immediate goal of the farm operator is to make a profit, this may not be his ultimate goal. Other goals of the farm firm that may yield maximum satisfaction include security (minimizing risk or income stability), prestige (maximum power or public image), market domination (maximum sales revenue with or without a profit constraint), self-employment, and minimum effort. These goals will influence mangement decisions and result in less than maximum profits.

The extent to which a farmer strives to maximize profit will depend upon his beliefs, values, attitudes, personality traits and interests, family goals, and desired leisure activities. When the objective is to maximize profits, the degree of success will depend upon the operator's management ability subject to the following obstacles: lack of information, family health, attitude, education, community life, acquisition of the resources necessary

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[1] Daryl J. Hobbs and Allan A. Warrack, "Summary of Research on the Relation of Goals, Values and Attitudes to Farm Management Performance," in <u>The Management Factor in Farming: An Evaluation and Summary of Research</u>, (St. Paul, Minnesota: University of Minnesota, Agricultural Experiment Station, 1968), p. 17.

for farming, proper combination and management of land, labour and capital resources, selection and combination of enterprises, and risk and uncertainty with regard to weather conditions, disease, prices, and yields.

In addition to the factors listed above, the magnitude of income depends upon the size of business, climatic and soil conditions, labour, equipment and capital use efficiency, intensity of production, market conditions, and government relations (eg. taxes, subsidies, and regulations). In view of the many obstacles and decisions to be made by the farm operator, the importance of his managerial ability can not be overemphasized.

The Management Process and Decision Making

Because management is considered a vital component of agricultural production, it is essential that a logical approach be applied to the decision making process. Management is at work when the farmer (1) observes the situation about him; (2) recognizes a problem; (3) looks for possible solutions to the problem; (4) selects the best solution; (5) puts the best solution into effect; and (6) accepts all responsibilities and bears all consequences in addition to learning from the decision.

There are several farm management tools available to the manager[1] to assist him in making general decisions regarding how to

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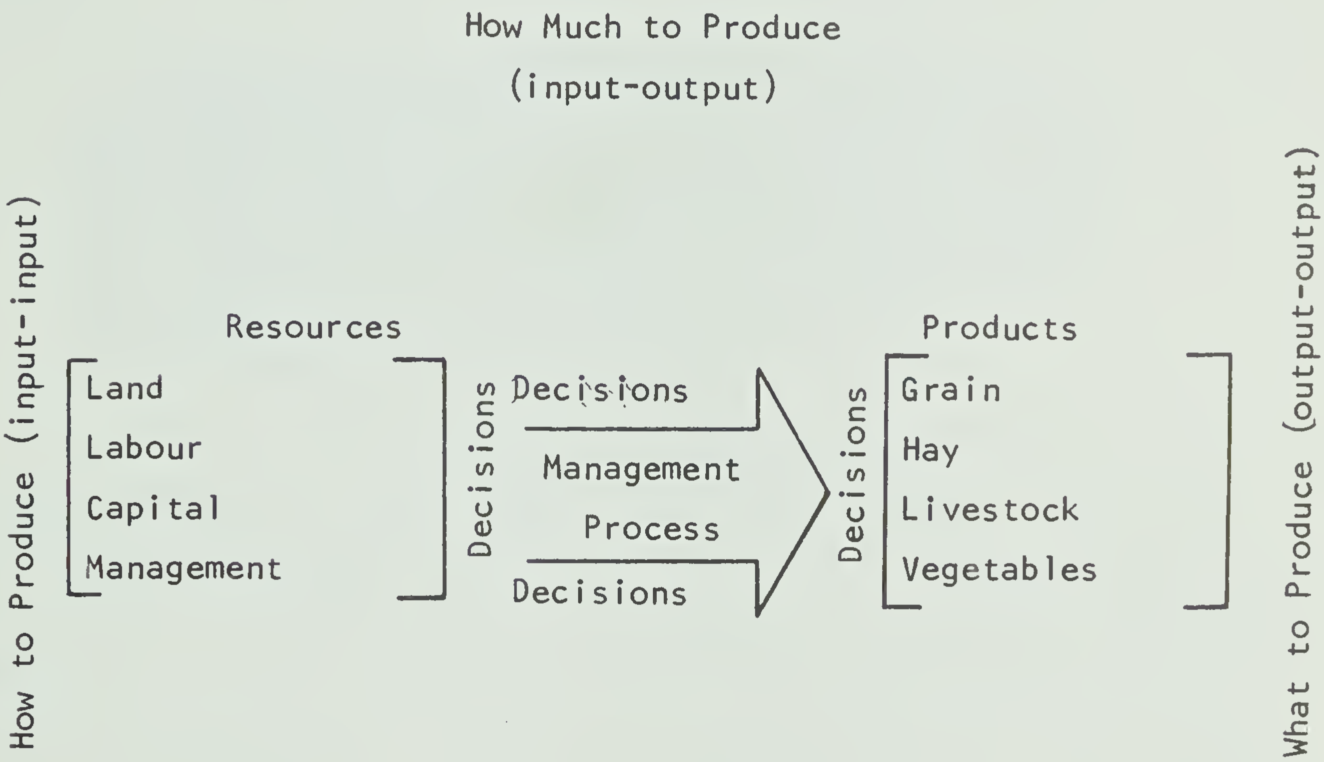
[1] "Manager" and "entrepreneur" are used interchangeably. Funk and Wagnalls' Standard College Dictionary, Canadian Edition, defines "manager" as one "...who directs or controls an enterprise, business, etc." An "entrepreneur" is "one who undertakes to start and conduct an enterprise or business usually assuming full control and risk."

produce, how much to produce, and what to produce (Figure 3). These tools include accounting, farm business analysis, budgeting, linear programming, research findings, and economic theory.

Figure 3

GENERAL TYPES OF FARM MANAGEMENT DECISIONS



Source: T. A. Petersen, Agricultural Economics 369 Lecture Notes (Edmonton: Department of Agricultural Economics and Rural Sociology, University of Alberta, 1970).

Farm records and accounts provide the basis for observing the situation on an individual farm. As outlined by Hopkins and Heady,[1] they provide physical and financial details on the previous year's operation and, therefore, have many uses. To be of any value in the decision making process, however, they must be analyzed.

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[1] Hopkins and Heady, op. cit., p. 7.

Approaches to Farm Business Analysis

Comparative analysis--The first attempt to an analysis using cost accounts was made by G. F. Warren at Cornell University. At a time when the supporting economic theory was relatively new, he introduced the approach of comparative analysis. In 1913 he stated:

> The best way to find out what methods of farm organization and management are most successful is to study the methods now used and the profits secured on large numbers of farms, and determine how the more successful ones differ from the less successful, and find to which of the differences the success is due. After such principles are found, they need to be tested by use in reorganizing farms.[1]

This initial approach to comparative analysis was done largely without the use of basic economic principles, which were not applied to farming until much later. It consisted of comparing each factor of the individual farm to the group averages of similar or surrounding farms. In this way it was intended to locate strong and weak points in the farm organization and in the operation of the business. As will be shown later, serious errors can arise when comparative analysis is applied without regard for farm management principles.

J. D. Black is credited for drawing economic principles to the attention of those concerned with farm management in the 1920's.[2]

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[1] Warren, op. cit., Preface.

[2] H. C. M. Case and D. B. Williams, Fifty Years of Farm Management (Urbana, Illinois: University of Illinois Press, 1957), p. 200.

The economic theories first incorporated into farm management were based largely upon the principles of diminishing returns and comparative advantage. Over the next thirty years, the principles of farm management as we know them today were developed and applied.

A hypothetical example is considered below to illustrate the advantages and disadvantages of comparative analysis. Table 2 lists some factors calculated from an individual farm account book with the corresponding group averages. The quality of grain and hay for X's farm is assumed to be similiar to the group average.

Table 2

HYPOTHETICAL DAIRY FARM

Factor	Individual X's farm	Average of all farms
Milk Production per cow (lbs)	10,000	9,000
Grain input per cow (lbs)	4,000	3,000
Hay input per cow (lbs)	7,500	6,500
P.M.W.U.[1] per M.E.[2] (days)	550	450
Equipment investment per M.E. ($)	18,000	13,000

[1]A productive man-work unit is the amount of work accomplished by one man using an average amount of equipment and working at a normal pace eight hours per day.

[2]A man equivalent is equal to the months of hired labour, family labour, and operator's labour divided by twelve months.

By ignoring farm management theory as a conceptual guide, the manager or the extension worker could conclude that individual X's farm is above average in milk production per cow and labour efficiency, but is feeding too much grain and has overinvested in equipment. A closer examination could produce different conclusions. Individual X has increased milk production (1,000 pounds above average) by feeding additional grain (1,000 pounds above average). If grain is worth two cents a pound and milk sells for five dollars per hundredweight, his net revenue would be thiry dollars more than had he been average in these factors. Futhermore, herd averages can be misleading in that the milk production per cow within the herd can vary considerably. Also an average does not tell the manager if resources (e.g., grain and hay) are being used in the least-cost combination and at appropriate levels to maximize profits. Thus even though individual X is above average in milk production, there may be room for profitable improvement.

It should be recognized that equipment substitutes for labour and, therefore, may account for the high labour efficiency. Further investigation is necessary to determine the optimum combination of labour and equipment. This is where production economics theory becomes a necessary addition to comparative analysis, which used by itself can lead to erroneous interpretation.

Despite its many pitfalls, comparative analysis can suggest possible weaknesses in the business (e.g., equipment investment per man equivalent from the example). It is not an end in itself in

recognizing problems but rather a "coarse tuning device"[1] in the management process and should be used as a guide with all of its inherent weaknesses in mind.

Economic theory of the firm--The second approach to a meaningful farm business analysis is the "fine tuning" with micro-economic theory, which focuses on the individual farm itself. Rather than using comparative analysis as outlined above, the manager can compare the results from his record analysis to experimental findings, supplemented by the relevant economic theory.

An abundance of research has been done showing the physical relationship between farm resources and farm products. Recommendations based on this research are available from universities, research stations, provincial extension personnel, and private companies. For example, a typical recommendation is that made by the USDA[2] for cows on good roughage. They recommend that Holstein cows be fed 0.4 lbs of grain per day for each pound of milk produced in excess of 16 pounds. The decision maker who assumes that his cows respond to additional feed in a manner similar to that of the cows used in a particular study would follow the recommendations based on the research. The manager may, however, use the research recommendations

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[1] T. A. Petersen, Associate Professor, Department of Agricultural Economics and Rural Sociology, University of Alberta, Conversation.

[2] United Grain Growers, The Grain Grower (1966), pp. 410-453.

as a guideline and experiment further with his own cows. In either case he should expand feed input as long as the added cost of the feed is less than the added return from the extra milk produced.

Research has shown that some inputs substitute for others. Grain, for example, can be substituted for hay up to a point while maintaining output at the same level. This permits the manager to adjust the amount of grain and hay in the dairy cow ration in response to changing prices for grain and hay. In other words, as the price of grain decreases, the amount of grain relative to hay in the livestock ration should be increased.

Combination of comparative analysis and economic theory--A third alternative for the farm business analyst is to combine comparative analysis and the economic theory of the firm. Having located possible weak spots in the farm operation with comparative analysis, the manager can then apply the relevant economic theory in decision making to increase his farm income.

Basic Economic Principles of Farm Management

The farm is an economic unit which approximates a firm in a perfectly competitive industry. Ferguson defines perfect competition in the following way:

> Perfect competition is an economic model of a market possessing the following characteristics: each economic agent is so small relative to the market that it can exert no perceptible influence on price; the product is homogeneous; there is free mobility of all resources, including free and easy entry and exit of business firms; and

> all economic agents in the market possess complete and perfect knowledge.[1]

These conditions imply that advertising is unprofitable, new technology is quickly adopted by all firms, artificial restraints on demand, supply, and prices by government are nonexistent, and there are no long run excess profits.

There are deviations in farming, however, from the characteristics of a perfectly competitive industry. The registered seed grower or purebred livestock producer, for example, has differentiated his product and, therefore, is able to influence its price to some degree. Advertising may be profitable in these instances. Entry or exit from the farming industry is not always easy, depending on the amount of capital involved. Also, the average farm manager does not have complete knowledge. Neither can he influence the price of his product (e.g., hogs); hence, he views the demand curve for the commodity as horizontal or perfectly elastic.[2] This is in contrast to the whole industry where price is determined by supply and demand conditions. Figure 4 illustrates this relationship.

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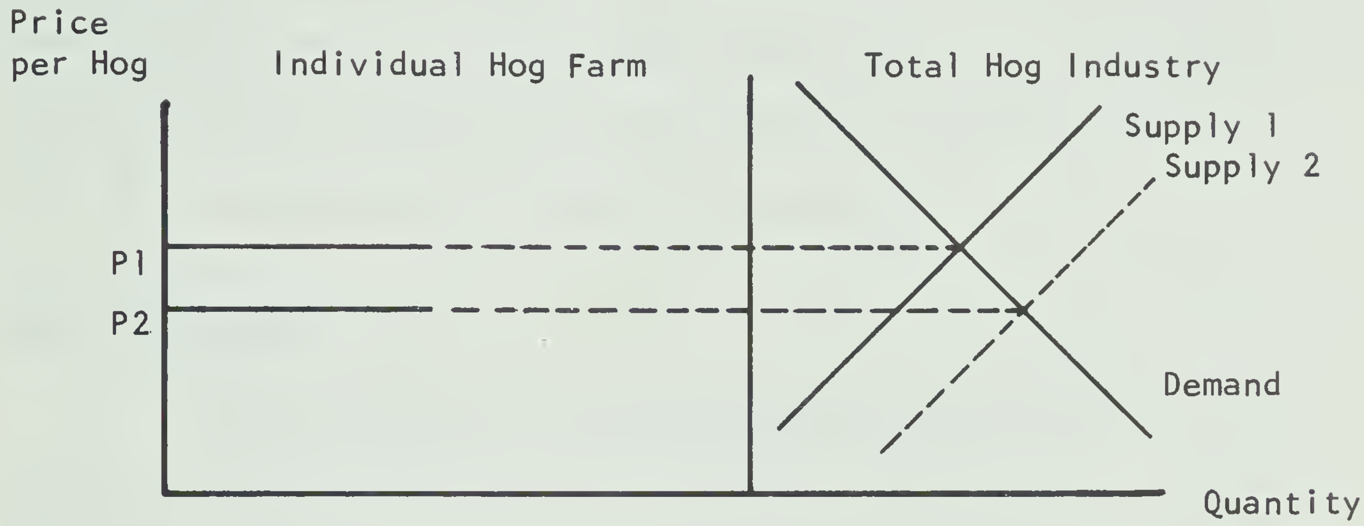
[1]C. E. Ferguson, Microeconomic Theory (Nobleton, Ontario: Richard D. Irwin, Inc., 1969), p. 224.

[2]Elasticity refers to the percentage change in quantity taken or applied divided by the percentage change in price.

Figure 4

PRICE DETERMINATION FOR THE
INDIVIDUAL FARM AND THE HOG INDUSTRY



Source: Adapted from Richard H. Leftwich, The Price System and Resource Allocation (New York: Holt, Rinehart and Winston, Inc., 1966), Fig. 3-7, p. 32.

When the supply of hogs equals the demand for hogs, equilibrium in the hog industry is said to exist at price P_1. An increase in supply is illustrated by a shift of the supply curve (S_2) resulting in a new equilibrium at P_2, all other factors remaining constant. Similarly, it can be shown that a decline in the demand for pork will result in a reduced price to the individual pork producer.

Because the farm manager is a price-taker, his decisions are concerned primarily with production. Economic theory and principles are applicable because the farm approximates a firm in a

perfectly competitive industry. As will be shown these principles are a useful tool for the decision maker in deciding how much to produce, how to produce, and what to produce. Before making these decisions, however, he must have some knowledge of the physical relationships between various inputs and outputs, the alternative inputs which are required for the production processes, and the alternative enterprises suitable for his farm.

Basic Principles

Factor-product or input-output principles--Once the size of a farm business has been established in the short run, the farm manager must decide upon the intensity of the operation and the level of output. This is the decision of "how much to produce."

The classical production function in Figure 5 shows output when a variable input is applied to fixed inputs. It illustrates the principle of diminishing returns.[1] Response from the use of varying amounts of fertilizer on specific crops is often used to illustrate the production function. A hypothetical example is presented in Table 3 to show the physical and economic results of adding various amounts of fertilizer to an acre of wheat. If the physical results are plotted on a graph, a production function with

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[1] This empirical generalization, sometimes called the Law of Diminishing Returns, can be stated as follows: If increasing amounts of one input are added to a production process while all other inputs are held constant, the amount of output added per unit of variable input will eventually decrease.

Table 3

HYPOTHETICAL EXAMPLE...THE PHYSICAL AND ECONOMIC

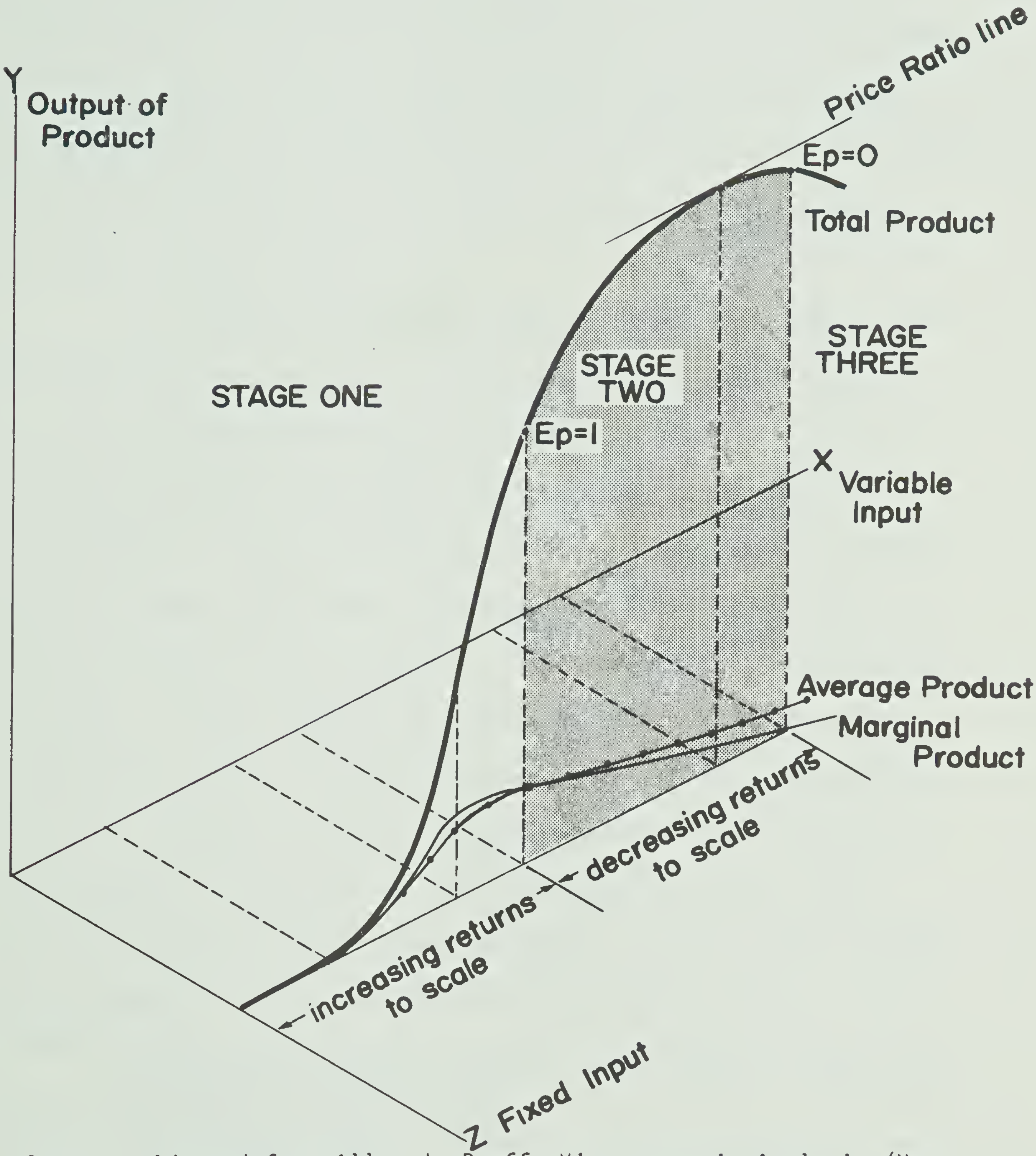
RESULTS OF ADDING VARIOUS LEVELS OF FERTILIZER TO AN ACRE OF WHEAT

	1 UNITS OF LAND	2 UNITS OF FERTILIZER APPLIED	3 TOTAL PRODUCT (BUSHELS)	4 MARGINAL PRODUCT	5 AVERAGE PRODUCT	6 MARGINAL VALUE PRODUCT	7 AVERAGE VALUE PRODUCT	8 MARGINAL FACTOR COST	9 NET REVENUE PER UNIT FERTILIZER	10 TOTAL REVENUE	11 TOTAL VARIABLE COSTS	12 TOTAL FIXED COSTS	13 TOTAL COSTS	14 PROFIT	15 AVERAGE VARIABLE COSTS	16 AVERAGE FIXED COSTS	17 AVERAGE TOTAL COSTS	18 MARGINAL COST	19 MARGINAL REVENUE
INCREASING RETURNS TO SCALE	1	0	0*		0		0			0	0	1.00	1.00	-1.00	0	0	0		
				1.0		1.20		.30	.90									.30	1.20
	1	1	1.0		1.00		1.20			1.20	.30	1.00	1.30	-.10	.30	1.00	1.30		
				1.4		1.68		.30	1.38									.21	1.20
	1	2	2.4		1.20		1.44			2.88	.60	1.00	1.60	1.28	.25	.41	.67		
				1.6		1.92		.30	1.62									.19	1.20
	1	3	4.0		1.33		1.60			4.80	.90	1.00	1.90	2.90	.23	.25	.48		
				2.0		2.40		.30	2.10									.15	1.20
	1	4	6.0		1.50		1.80			7.20	1.20	1.00	2.20	5.00	.20	.17	.37		
CONSTANT RETURNS TO SCALE				2.0		2.40		.30	2.10									.15	1.20
	1	5	8.0		1.60		1.92			9.60	1.50	1.00	2.50	7.10	.19	.13	.31		
				1.6		1.92		.30	1.62									.19	1.20
	1	6	9.6		1.60		1.92			11.52	1.80	1.00	2.80	8.72	.19	.10	.29		
DECREASING RETURNS TO SCALE				1.0		1.20		.30	.90									.30	1.20
	1	7	10.6		1.51		1.81			12.72	2.10	1.00	3.10	9.62	.20	.09	.29		
				.8		.96		.30	.66									.38	1.20
	1	8	11.4		1.42		1.70			13.68	2.40	1.00	3.40	10.18	.21	.09	.31		
				.6		.72		.30	.42									.50	1.20
	1	9	12.0		1.33		1.60			14.40	2.70	1.00	3.70	10.70	.23	.08	.31		
				.4		.48		.30	.18									.75	1.20
	1	10	12.4		1.24		1.49			14.88	3.00	1.00	4.00	10.88	.24	.08	.32		
				.3		.36		.30	.06									1.00	1.20
	1	11	12.7		1.15		1.38			15.24	3.30	1.00	4.30	10.94	.26	.08	.34		
				.2		.24		.30	-.06									1.50	1.20
	1	12	12.9		1.07		1.28			15.48	3.60	1.00	4.60	10.88	.28	.08	.36		
				.1		.12		.30	-.18									3.00	1.20
	1	13	13.0		1.00		1.20			15.60	3.90	1.00	4.90	10.50	.30	.08	.38		
NEGATIVE RETURNS				0		0		.30	-.30									∞	1.20
	1	14	13.0		.93		1.12			15.60	4.20	1.00	5.20	10.40	.32	.08	.40		
				-1.0		-.12		.30	-1.50									∞	1.20
	1	15	12.0		.80		-1.20			14.40	4.50	1.00	5.50	8.90	.38	.08	.46		
			PHYSICAL RESULTS				($) PER UNIT INPUT				TOTAL COSTS AND RETURNS ($)					($) PER UNIT OUTPUT			

*THE RESULTS SHOWN IN THIS TABLE ARE ATTRIBUTED TO THE ADDITION OF FERTILIZER (VARIABLE INPUT) TO THE FIXED INPUT (ONE ACRE OF LAND). THEREFORE, THE FERTILIZER RESPONSE IS 0 BUSHELS OF WHEAT WHEN FERTILIZER IS NOT APPLIED.

Figure 5

FACTOR-PRODUCT RELATIONSHIP



Source: Adapted from Allan J. Braff, Microeconomic Analysis (New York: John Wiley and Sons, Inc., 1969), Fig. 4.3-4.4, pp. 49-50.

the corresponding marginal[1] and average[2] product curves similar to those in Figure 5 will be obtained. It should be noted that stage one of the fertilizer production function is usually very small or nonexistent, as is the case in most agricultural production processes. With a knowledge of the fertilizer response (production function), the recommended type of fertilizer to use (for example, 11-48-0), and the prices of the input and the output, the manager must decide at what level to apply the fertilizer.

In stage one the marginal physical product is greater than the average physical product. As the average physical product is increasing throughout this stage, the efficiency of the variable input (fertilizer) is increasing, and the fixed input (land) is underutilized. This is often referred to as the area of increasing returns to scale. For these reasons output should be extended to at least the lower limit of stage two if the product has a value greater than zero. The only reasons for operating in stage one would be insufficient demand to permit taking advantage of increased productivity or a shortage of variable inputs. The boundary of stages one and two occurs at the point on the total physical product curve where the average product is at its maximum. At this point the percentage change in output is equal to the percentage change in input.

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[1]The marginal physical product is the change in total output per unit change in variable input.

[2]The average physical product is the total output divided by the total variable input.

We, therefore, have a condition of constant returns to scale or an elasticity of production equal to one (Ep = 1).

Stage three is also an irrational area of production because output can be increased by withdrawing some of the variable input, or in the long run, the producer could increase the amount of resource previously considered fixed. In other words, he could use the same total amount of fertilizer on more land.

Without a knowledge of prices the manager should conclude that the best area of production is stage two of the production function with decreasing returns to scale.

Because maximum profit represents the greatest difference between total revenue and total costs, the manager must consider the prices of the inputs and output in determining the optimum intensity of production in stage two. Costs[1] are the expenses incurred in organizing and carrying out the production process. The two major categories of short run costs are fixed and variable costs. In the long run, all costs are variable. Fixed costs do not vary with output. They include real estate taxes, rent and interest on capital, insurance premiums, annual hired labor, building depreciation, and equipment depreciation. Variable costs refer to those outlays which are a function of output in the selected production period. They change with the change in output. These costs include fuel, machinery repairs, purchased feed, livestock purchases and expenses, custom work, and crop supplies. Total costs (fixed costs plus

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[1] C. E. Bishop and W. D. Toussaint, Introduction to Agricultural Economic Analysis (New York: John Wiley and Sons, Inc., 1958), p. 70.

variable costs) are dependent upon the method of production, and the cost and productivity of the resources. Total revenue is calculated from the formula: quantity produced times price per unit.

There are several methods of determining the optimum level of inputs, all of which yield the same answer. Perhaps the easiest method is to use the production function and the price ratio line, as shown in Figure 5.

If Px refers to the price of the variable input X and Py refers to the price of the output Y, maximum profits are obtained when the following condition is met:

$$\text{(i)} \quad \frac{\text{Price of Input X}}{\text{Price of Product Y}} = \frac{\Delta Y}{\Delta X}$$

$$\text{or} \quad \text{(ii)} \quad Px\ \Delta Y = Py\ \Delta Y$$

This is illustrated by the tangency of the price ratio line with the total product curve. The quantity of variable input X_1 should be used. At this point the marginal factor cost (Px ΔX) is equal to the marginal value product (Py ΔY). By applying X_1 units, the farm manager has extracted all possible profit from the use of input X_1.

In the example outlined in Table 3, fertilizer (X) is valued at thirty cents per unit, (Px), and one bushel of wheat (Y), is valued at one dollar and twenty cents (Py). If the amount of fertilizer is increased from 5 to 6 units (ΔY = 6-5 = 1), there is a corresponding increase in wheat production from 8 to 9.6 bushels (ΔY = 9.6 - 8 = 1.6). Utilizing the above formulas, the

following results are obtained:

(i) $\frac{.30}{1.20}$ is less than $\frac{1.6 \text{ bushels}}{1 \text{ unit fertilizer}}$

or (ii) .30 x 1 unit is less than \$1.20 x 1.6 bushels.

Since the input-output price ratio is less than the marginal produce ($\frac{\Delta Y}{\Delta X}$) or the added costs (marginal factor cost) are less than the added return (marginal value product), profits can be increased by greater use of the variable input. The individual must, therefore, farm more intensively. By applying between ten and eleven units of fertilizer, profits can be maximized between \$10.88 and \$10.94 (column 14). Profits are not maximized when the average product is at the maximum. The maximum average product criterion is used only when there are scarce inputs.

The discussion of "how much to produce" has assumed that revenue is greater than the costs of production. As was pointed out in Figure 4 and applied in Table 3, the price of the product on the output side is constant regardless of the volume of production. The additional revenue from each additional unit of output is equal to the price of the product. In the short run the farm manager should set output of a particular enterprise at the point where marginal cost is equal to the price of the product, providing that price is greater than or equal to the average variable cost. Under this condition the farm is covering all variable costs and perhaps part of the fixed cost. If the price is less than the average variable cost in the short run, the wise decision would be to stop

production and thus minimize losses. In the long run all costs must be covered. Otherwise production should be stopped.

Factor-factor or input-input principles--Farm production usually involves more than one variable input. The farm manager must then determine the least-cost combination of the appropriate inputs in order to minimize costs. It, therefore, becomes a decision of "how to produce."

In the case of inputs that must be combined in fixed proportions, it is only a matter of whether or not to use them. A tractor and the fuel it uses must be combined in a certain proportion. One cannot be substituted for the other. Their relative prices are of no consequence because they have a fixed rate of substitution.

The relative prices of inputs which substitute at a constant rate must be considered. Number one feed barley, for example, substitutes perfectly for number two feed barley. In this instance one simply uses the cheapest input available.

Inputs which substitute for one another at a varying rate pose a more complex problem. The substitution of grain for hay in a dairy cow ration or the substitution of machinery for labour are examples on the farm of cases in which the substitution of one input for another occurs at a diminishing rate. Decreasing rates of marginal substitution caused by the law of diminishing returns occur when the input being increased substitutes for smaller and smaller amounts of the input being replaced. This is

illustrated in the dairy cow example in Table 4. To maintain a constant output of 5300 pounds of milk, each additional 500 pounds of grain replaces smaller and smaller amounts of hay.

Table 4

FEED COMBINATIONS IN PRODUCING

SPECIFIED MILK LEVELS FOR 26 WEEKS

Pounds of Grain	Pounds of Hay Required to Produce Pounds of Milk (per cow)		
	5300	6300	7300
1000	5560	8256*	11138*
1500	3969	6566	9328*
2000	2558	5074	7738*
2500	1313	3761	6345
3000	221*	2612	5130
3500		1616	4080
4000		763*	3182
4500			2428
5000			1813

*Prediction is outside range of observations.

Source: Earl O. Heady and John L. Dillon, Agricultural Production Functions (Ames, Iowa: Iowa State University Press, 1961), Table 12.9, p. 420.

The isoquants[1] obtained by plotting the data in Table 4 for each level of output approximate the theoretical input-input

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[1]The curve representing all combinations of two variable inputs that produce a given level of output is called an isoquant.

relationships illustrated in Figure 6.

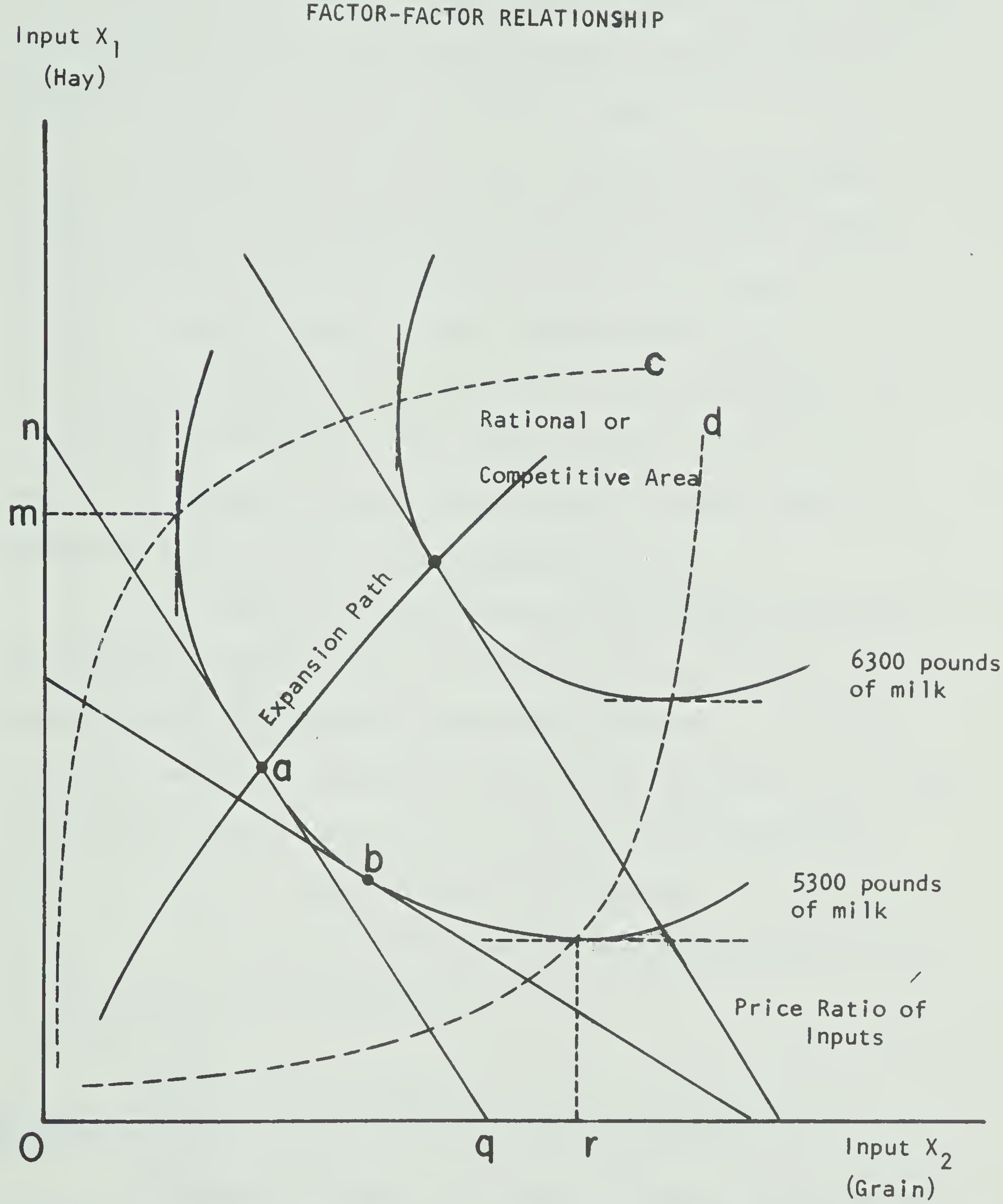
In some instances the variable input is not completely divisible. These are referred to as "lumpy inputs." Even though the resulting isoquant is not a smooth curve, the economic principles of cost minimization still apply. It should be emphasized that each input must have been produced within stage two of the production function prior to being utilized for the production of another product in order to maximize profits. The areas of irrational and rational resource combination are shown in Figure 6. Any combination of inputs above om or beyond or is irrational because factors can be rearranged to give the same product using less of both resources. A knowledge of prices is not required to make this adjustment.

The price of inputs, represented by the price ratio line in Figure 6, is required to determine the exact point within the rational area of production. Profit maximization occurs at the point where the marginal rate of substitution of the inputs ($\frac{\Delta X_1}{\Delta X_2}$) is equal to the inverse price ratio ($\frac{Px_2}{Px_1}$). This is represented by the tangency of the price ratio line to the output isoquant at point A. It is equivalent to $Px_1 \Delta X_1 = Px_2 \Delta X_2$. If the reduced costs exceed the added costs (e.g., if $Px_1 \Delta X_1$ is greater than $Px_2 \Delta X_2$), then it pays to increase the input of X_2 and reduce the input of X_1, with the output level remaining the same.

With unlimited capital, profit maximization involves extending output (moving out the expansion path) as long as the added revenue exceeds the added cost.

Figure 6

FACTOR-FACTOR RELATIONSHIP



Source: Adapted from Richard H. Leftwich, The Price System and Resource Allocation (New York: Holt, Rinehart and Winston, Inc., 1966), p. 125.

Product-product or output-output principles--The discussion thus far has considered the optimum level at which to use a variable input and the cheapest combination of inputs. Probably the most important decision, however, is "what to produce."

In accordance with the law of comparative advantage, managers should produce those things (considering yields, costs, and prices) from which their relative or percentage returns are the greatest.[1] With unlimited capital, production for each enterprise should be extended until the cost of the input and the added value of the product per unit of input (MVP) are equal. As is usually the case, the manager cannot undertake every desirable enterprise because of limited capital and management ability.

The theoretical approach to choosing between two alternative enterprises with a capital limitation is the production possibility or transformation curve shown in Figure 7. Developed from their respective production functions, it represents the various combinations of the outputs Y_1 and Y_2 which can be produced at a given total cost.[2] It may, therefore, be referred to as an isocost curve. (It is assumed that the inputs for each output are utilized in their least-cost combination.)

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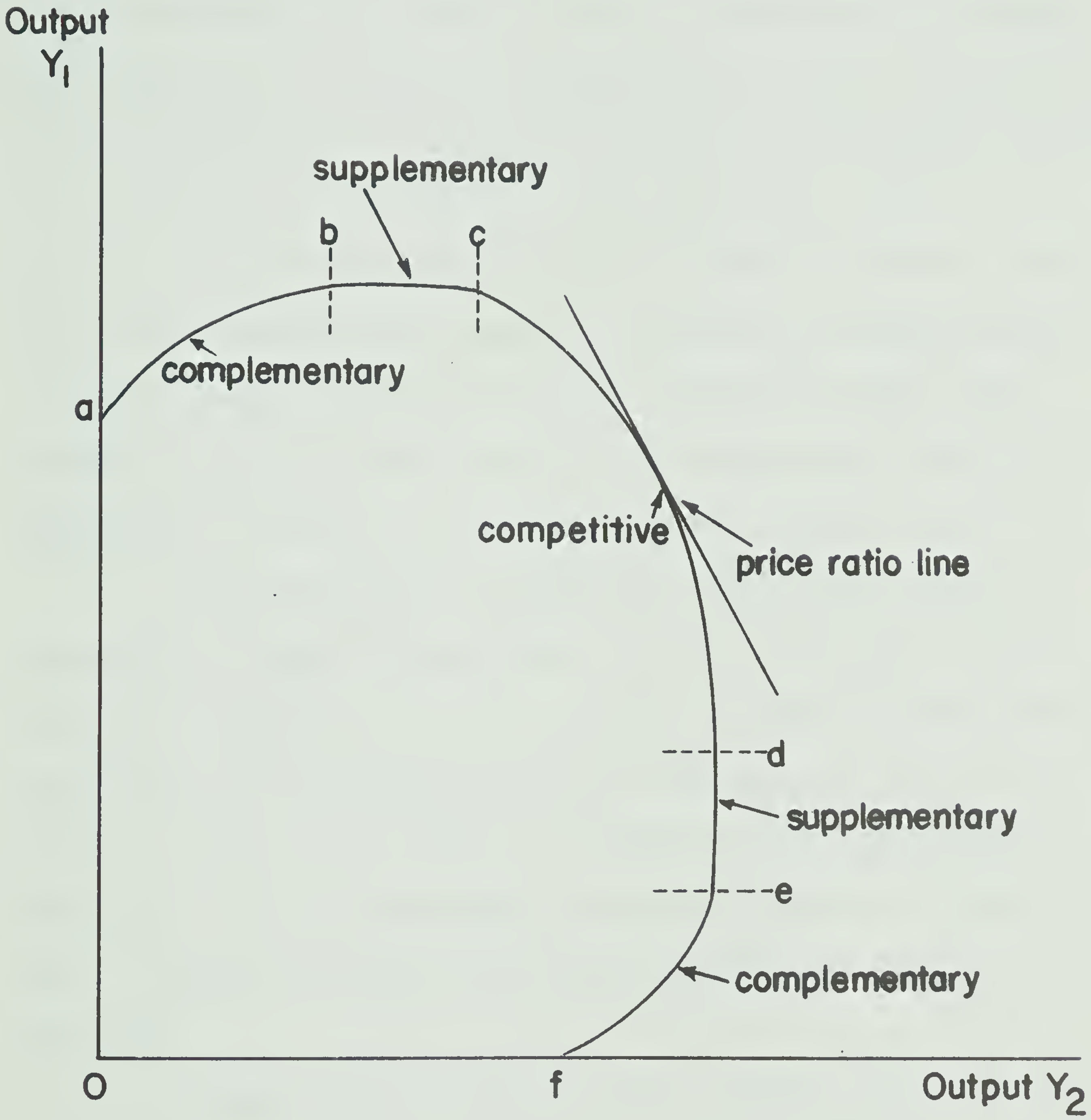
[1]Earl O. Heady and Harold R. Jensen, Farm Management Economics (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1954), p. 47.

[2]Lawrence A. Bradford and Glenn L. Johnson, Farm Management Analysis (New York: John Wiley and Sons, Inc., 1953), p. 156.

Figure 7

PRODUCT-PRODUCT RELATIONSHIP



Source: Adapted from John P. Doll, V. James Rhodes, and Jerry G. West, Economics of Agricultural Production, Markets, and Policy (Nobleton, Ontario: Richard D. Irwin, Inc., 1968), Figs. 6-4 and 6-5.

Various physical relationships of products can occur. Those of most concern to the farm manager are complementary, supplementary, and competitive products. Two products are complements when an increase in the output of one, with resources held constant, also results in an increase in the output of the other. An example of this relationship is a rotation of grain and grass-legume mixture on grey wooded soils of Alberta. The complementary region of the production possibility curve (ab and ef) as shown in Figure 7 should be avoided as greater total output is available by extending production to at least the boundaries of the competitive region. Hay production should be substituted for grain production at least until additional hay results in no further increase in grain output.

Two enterprises are supplementary when, with resources constant, the output of one product can be increased with neither a gain nor a sacrifice in another product. A small livestock enterprise which utilizes excess labour and some machinery during the winter months on a grain farm is an example of this relationship. The output from the supplementary enterprise should be increased until it begins to compete with other enterprises for limited resources.

Without any knowledge of prices, movement outward to the production possibility curve will increase income (providing product prices are greater than zero). Movement along the curve, from either the complementary region or the supplementary region, will also increase total output.

Maximum profits are attained when the marginal rate of product substitution is inversely equal to the ratio of the output prices. At this point the price ratio line is tangent to the transformation curve:

$$\frac{\Delta Y_1}{\Delta Y_2} = \frac{Py_2}{Py_2}$$

or

$$Py_1 \Delta Y_1 = Py_2 \Delta Y_2$$

If the added returns ($Py_1 \Delta Y_1$) exceed the reduced returns ($P_2 \Delta Y_2$), then it pays to increase the output of Y_1 and, therefore, decrease Y_2 output. Input levels and total cost remain unchanged. Any change in the ratio of the output prices will call for a change in the quantity of output Y_1 relative to output Y_2 in order to maintain profits at a maximum. For the overall maximization of farm profits, the conditions for profit maximization under input-output, input-input, and output-output relationships must hold simultaneously.

Consider the case where the products of some enterprises are not sold but used as inputs for another enterprise. The production of forage and grain for livestock feed is a good example. This is illustrated in Figure 8. To maximize profits the following conditions must be met:

1. The production of forage and grain must take place in stage two of their respective production functions;

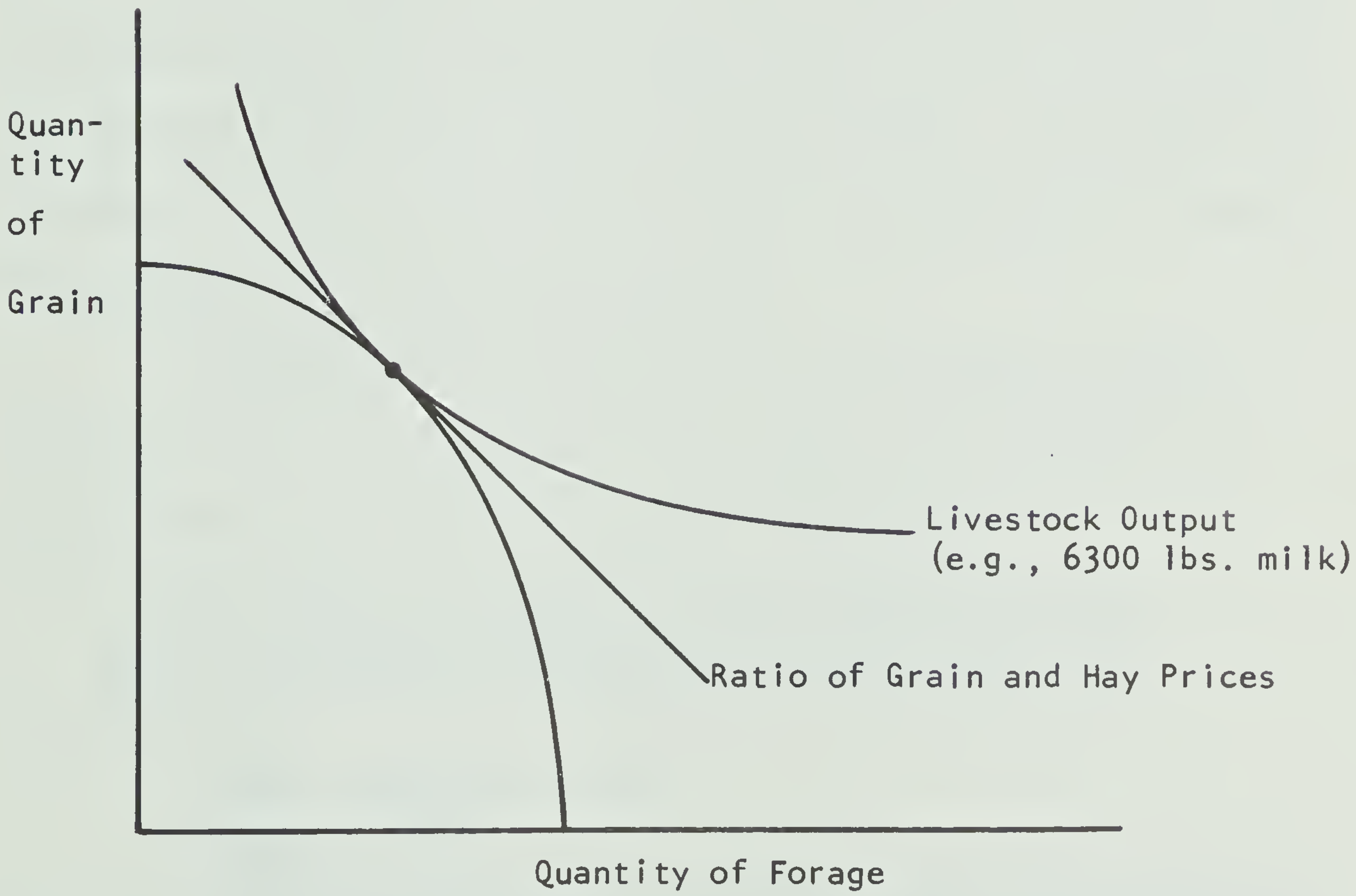
2. The combination of grain and hay in the livestock ration must be utilized in a least-cost combination;

3. Because the price of the grain or of the hay is the same whether bought or sold on the market, the marginal rate of output substitution in the crop rotation must equal the marginal rate of feed substitution in the livestock ration.

Figure 8

MAXIMUM LIVESTOCK PRODUCTION

FROM A GIVEN QUANTITY OF LAND



Source: Earl O. Heady, Economics of Agricultural Production and Resource Use (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1952), Fig. 15, p. 261.

It is conceivable that to satisfy the above conditions the farm manager may find it necessary to sell some grain and buy some hay, or vice versa.[1] The situation is complicated further when inputs can be shifted between enterprises. In this instance, the marginal rate of substitution for the inputs must be equal for both outputs.[2]

Opportunity cost and equimarginal returns--Two important farm management principles which help to link together the rules of profit maximization are opportunity cost[3] and equimarginal returns. Suppose the farm manager purchases a new tractor with borrowed money obtained at 10 percent interest rather than fertilizer, which would have yielded a 50 percent return on the investment. The actual cost (opportunity cost) of the borrowed money is then 50 percent because of the returns which have been foregone.

Since opportunity cost underlies the concept of equimarginal returns, a definition of the former often includes the latter. Heady and Jensen have stated the following:

> The principle of opportunity cost says that we have the best combination of enterprises or practices from our limited resources when they are so organized that

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[1] Heady, *op. cit.*, p. 266.

[2] *Ibid.*, p. 271.

[3] The opportunity cost of an input is the return which must be given up when the input is not used in its best alternative use.

> we can't change the use of a single dollar or a day's labor without reducing income. It is called opportunity cost because it considers the value of one enterprise sacrificed as a cost in producing another enterprise.[1]

In other words, to have equimarginal returns the farm manager should use his limited capital so that the added returns from the last dollar or unit of money invested in each enterprise are equal. By comparing a number of partial budgets of suitable enterprises, the manager can estimate the effects of investing his limited capital at various levels in different enterprises. He can, therefore, distribute his capital so as to maximize the return on his investment.

Time comparisons--The discussion thus far has been based on what is referred to as static equilibrium theory. It assumes a timeless production period under conditions of absolute certainty, infinitely divisible inputs, and no capital gains or losses. In the real world, however, time does affect the production process, which leads to such factors as risk and uncertainty. Also the length and nature of the production process varies according to the type of enterprise and from one production period to the next. This affects both costs and revenues. The income from one enterprise may begin this year, while the income from another enterprise may not start for several years. To obtain a fair comparison of various alternatives, they should be compared in the same time period. This can be done by using mathematical formulas and financial tables.

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[1]Heady and Jensen, op. cit., p. 79.

The formula for discounting future lump sums of money back to the present is as follows:

$$\text{(i) Present Value} = \frac{\text{Future Value}}{(1 + \text{interest rate})^{\text{Years}}} .$$

The present value of an income stream with a limited time period is found with the formula:

$$\text{(ii) Present Value} = \frac{\text{Equal annual net revenue}}{\text{Interest rate}} \text{X} \left[1 - \frac{1}{(1 + \text{interest rate})^{\text{Years}}} \right]$$

Buildings and breeding stock are in this category. If the time period is infinite, we obtain the following:

$$\text{(iii) Present Value} = \frac{\text{equal annual net revenue}}{\text{interest rate}} .$$

The value of land may be determined by this method. This value may not, however, correspond to the market price of the land. If the annual revenue is not assumed to be constant throughout the life of the resource, the present value can best be estimated by using the equation:

$$\text{(iv) Present Value} = \frac{R_1}{(1 + i)^1} + \frac{R_2}{(1 + i)^2} + - - \frac{Rn}{(1 + i)^n} ,$$

where R = annual net revenue in each specified year,

and i = interest rate.

In the case of a resource which has a limited life (e.g., a barn) and is part of a resource with a perpetual income (e.g.,

land), the following equation is appropriate:

$$(\text{v})\quad \text{Present Value} = \frac{R}{i} + \frac{R^1}{i}\left(1 - \frac{1}{(1+i)^n}\right),$$

where R = constant annual net revenue from the perpetual flow resource (land)

R^1 = constant annual net revenue of the terminable portion, such as the barn

i = interest rate or discount rate

n = life expectancy in years of the terminable resource.

The present value of a resource with a terminable flow of services and variable income is given by the formula:

$$\text{Present Value} = \frac{\text{Annual Net Revenue}}{\text{interest rate}} \pm \frac{\text{equal annual change in revenue}}{(\text{interest rate})^2}.$$

The formula could be used to incorporate capital gains or losses into the discounting procedure by substituting the equal annual change in value in the above equation.

The same formulas can be used for discounting costs by substituting costs for net revenue. This technique would be useful in comparing various machinery investment alternatives.

Financial tables and the above formulas provide a useful tool to the farm manager in decision making. Deciding "when" to produce will be influenced by the manager's preference for income in one time period rather than in another. The individual's time preference, which determines how heavily he discounts future income or costs, is influenced by one or more of the following factors:

1. the degree of uncertainty visualized by the individual;

2. the market rate of interest or external rate of return;

3. a shortage of capital and the need for present consumption;

4. the internal rate of return;[1]

5. goals for achieving power or status and wealth; and

6. the age of the individual.

Risk and Uncertainty

The most important factor complicating the decision making process is that of risk and uncertainty. Imperfect knowledge of the future affects the application of economic principles and the way in which farm records are used to treat farm management problems. The manager's expectations, conditioned by his personality, knowledge, and financial position, will determine the precautions taken to meet the risk and uncertainty. Cautiousness on his part will result in a less than optimum level of variable inputs, the establishment of more predictable production that yields an immediate income, and the utilization of safeguards, such as diversification and insurance. The result is less than maximum profits for the farm business but perhaps a more stable income.

Risk[2] refers to an outcome which is measurable in an

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[1]The internal rate of return is the rate of return realized by investing money in the farm business.

[2]Heady, op. cit., pp. 440-443.

empirical or quantitative manner whereas uncertainty cannot be measured. Crop damage from hail is classified as risk because the past occurrence and damage from hail can be used to determine the probability of hail for a particular area. Losses from soil erosion are not measurable, therefore, are uncertain.

Several areas of risk and uncertainty confront the manager. The price inputs or outputs can change, especially the latter. The yields of crops and livestock vary depending upon the weather, disease, and insects. The laws and regulations respecting price supports, production controls, and credit policies are also uncertain. Related to institutional uncertainty is the export uncertainty of some commodities, for example, wheat, which affects the amount sold by the individual grain farmer. Family health, especially that of the farm manager, is unpredictable. New discoveries and developments in both production and marketing cause technological uncertainty. Finally, there are unpredictable actions of other people (e.g., government, bankers, employees) with whom the manager does business.

Insurance is available to cover elements of risk such as fire, death, or crop failure. For uncertainty, insurance is not available, and other strategies are necessary. For example, items such as loss to rodents, soil erosion, and yield fluctuations can be guarded against by control measures and good farming practices. There are also other methods by which the manager can reduce the amount of uncertainty. By means of commodity contracts with the buyer or seller, the manager can ensure a price and/or a market

for his product. Vertical integration can also be used for the same purpose. Examples of vertical integration are where a broiler enterprise is closely associated with a feed mill or a large feedlot operator owns his own packing plant. Hedging on the commodity futures market can be used to transfer price uncertainty and establish the price which the farmer will receive for his product. Another approach is to organize production so that it can be easily changed. The construction of a building, for example, which can be easily converted to a different type of production or maintaining assets which can be readily changed into cash are examples of flexibility. The manager who restricts the amount of borrowed capital practices internal credit rationing and increases his flexibility. Land used for annual crops affords greater flexibility than land used for an orchard. The landowner who rents his land to another individual on a cash rental basis eliminates a lot of uncertainty.

Despite the many precautions which can be taken, risk and uncertainty still dominate the farm business. Determination of the frequency and probabilities of certain outcomes is a relatively new field in agriculture and farm management. In many instances the farmer has formed his own opinion on the probability of success or failure of a given action. This may have come from intuition, trial and error, or watching neighbors. Whatever the case, the manager's outlook on future actions will likely change with the experience of continually making decisions and learning from them.

Practical Application of Farm Management Principles

Marginal Analysis Concept in Research and Farm Management Decisions

Studies in agriculture designed to incorporate marginal analysis have been limited. Iowa State University is noted for its contribution in this area. Table 4 gives the results of such a study where the objective was to determine the marginal rate of substitution of one feed for another. As outlined on page 43 profit maximization occurs at the point where the marginal rate of substitution of the inputs ($\frac{\Delta X_1}{\Delta X_2}$) is equal to the inverse price ratio ($\frac{Px_2}{Px_1}$).

If the price of grain (Px_2) is two cents a pound and hay is worth one cent a pound (Px_1), the optimum combination of inputs using the above formula for 6300 pounds of milk from Table 4 is determined in the following manner:

Lbs of Grain (X_2)	Lbs of Hay (X_1)	$\frac{\Delta X_1}{\Delta X_2}$	$\frac{Px_2}{Px_1}$
1000	8256		
		$\frac{1690}{500} = 3.4$	$\frac{2}{1} = 2$
1500	6566		
		$\frac{1492}{500} = 3.0$	$\frac{2}{1} = 2$
2000	5074		
		$\frac{1313}{500} = 2.6$	$\frac{2}{1} = 2$
2500	3761		
		$\frac{1149}{500} = 2.3$	$\frac{2}{1} = 2$
3000	2612		
		$\frac{996}{500} = 2.0$	$\frac{2}{1} = 2$
3500	1616		

At the given prices, the cheapest combination is 3500 pounds of grain and 1616 pounds of hay for the same twenty-six week period (Point B in Figure 6). If the price of grain increased relative to the price of hay, additional hay should be used in the ratio. The optimum combination of inputs would then be at a point such as A in Figure 6.

Partial Budgeting and Marginal Concepts

Another way of utilizing microeconomic theory in farm business analysis is by means of partial budget. A budget is defined as an estimation of possible changes in costs and returns in a given

time period when there is a contemplated change in the use of production resources.[1] It incorporates several farm management principles from microeconomic theory in addition to the concept of marginality (i.e., additional returns vs. additional costs). Partial budgeting as outlined in Figure 9 is the appropriate tool to use when adjustments in an ongoing farm business only affect a portion of the business. Only if a manager is starting a completely new farm or planning a major reorganization would he use the complete budget method, where all expected receipts and expenses from the whole farm are included.

Proposed changes in a farm business can be of three basic types: (a) resources can be added to or withdrawn from an enterprise or farm, (b) one resource can be substituted for another, and (c) one enterprise can be added, deleted, or substituted for another. In microeconomic theory these are referred to as "input-output," "input-input," and "output-output" models respectively. The partial budget form incorporates all these possibilities. For example, Sections A and C of the partial budget form correspond to the input-output relationship. The input-input principle is represented by B and C, with A and D corresponding to the output-output relationship.

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[1] Irving F. Fellows, ed., <u>Budgeting</u> (Storrs, Connecticut: University of Connecticut, 1962), p. 11.

Figure 9

THE PARTIAL BUDGET FORM

A D V A N T A G E S	A. ADDED RETURNS (livestock sales, crop sales, custom work, etc.) Total Added Returns ________ B. REDUCED COSTS 1. Fixed Costs (depreciation, interest, insurance. etc.) Total Reduced Fixed Costs ________ 2. Variable Costs (repairs, feed, fuel, electricity, etc.) Total Reduced Variable Costs ________ TOTAL ADVANTAGES ________
D I S A D V A N T A G E S	C. ADDED COSTS 1. Fixed Costs Total Added Fixed Costs ________ 2. Variable Costs Total Added Variable Costs ________ D. REDUCED RETURNS Total Reduced Returns ________ TOTAL DISADVANTAGES ________
	Estimated Change in Net Farm Income ________ Advantages - ________ Disadvantages = ________ Change

Source: Adapted from Alberta Department of Agriculture, 1966 Alberta Farm Business Report, Publication 819.50-30 (Edmonton: ADA, 1967).

Using the partial budget, the farm manager can get some idea of where an enterprise on his farm is situated relative to the economic optima described earlier. The right-hand side of the equation $P_x \Delta X = P_y \Delta Y$ (a condition for profit maximization) corresponds to the added returns section (A) of the partial budget form, whereas the left-hand side is equivalent to the added costs section (C). If the added returns ($P_y \Delta Y$) exceed the added costs ($P_x \Delta X$) of a proposed change in the farm business, it will pay to increase the variable input (for example, livestock feed or fertilizer) and, therefore, output. In this way the manager has determined that a particular enterprise is below the optimum, and he knows how to improve the situation.

By comparing the reduced costs section of the partial budget to the added costs, the farm manager can determine if a proposed change in the combination of inputs will increase his net farm income. If partial budgeting reveals that it pays to increase the amount of grain and decrease the quantity of hay in a livestock ration, while maintaining output at the same level, then the farm manager should recognize that he is to the left of point A or B of Figure 6. By comparing the added returns to the reduced returns in the partial budget form, any proposed change in the combination of enterprises which increases net farm income should be undertaken. In this way, the farmer is moving toward the optimum combination of enterprises. The effects of adding another enterprise, substituting one enterprise for another, or deleting an enterprise can also be ascertained with partial budgeting.

When looking for possible solutions to a problem, many alternatives can be compared using successive partial budgets. This is a weakness of the budgeting process in that it is a time-consuming, trial and error process. Partial budgeting is a powerful tool, however, and is adequate for solving many farm management problems. When the number of alternatives becomes large, the manager may resort to a more sophisticated approach involving a computer and linear programming.

For partial budgeting to be of any value, the data (input-output coefficients and prices) must be reasonably accurate. If the physical relationships between inputs and outputs are not accurate or the prices used are not reasonable, than the decision maker will arrive at incorrect conclusions. Data for partial budgeting can be obtained from the manager's own farm records, farm surveys and statistics, and research data. Product prices can pose a problem because of uncertainty. Adjusting the average price of a product over the past five years with outlook information is one approach in partial budgeting.

This chapter has dealt with farm management objectives, the managerial process, and economic principles underlying the decisions for optimal use of farm resources. It is suggested that comparative analyis alone can be rather sterile, perhaps even misleading, as a guide for the farm manager in planning his business.

CHAPTER IV

DATA

Source

The data for this study were obtained from the Economics Division, Alberta Department of Agriculture. They represent the farm account records of 354 Alberta farms that participated voluntarily in the Alberta Farm Business Analysis Program in 1967.

Nature

Three hundred and eighty-three farms were available, but not all records were used. Several records were incomplete. Farms reporting a zero net worth were excluded because it was considered doubtful if such a situation existed. Irrigation farms were excluded because of the nature of their operation. Data received too late for inclusion in the 1967 reports[1] was also deleted.

The records used do not represent a random sample of Alberta farms. Participation in the farm business analysis program is on a voluntary basis with one exception. Farms being purchased

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[1]Alberta Department of Agriculture, 1967 Alberta Farm Business Analysis Report, Publication No. 819.50-41 (Edmonton: ADA, 1968).

________, 1967 Alberta Cow-Calf Enterprise Analysis, Publication No. 816.420-7 (Edmonton: ADA, 1968).

________, 1967 Alberta Cattle Feeding Enterprise Analysis, Publication No. 816.420-9 (Edmonton: ADA, 1968).

under the Veterans Land Act are required by the Federal authority to be on the program. It is assumed, however, that better than average farmers participate. Average size of farm in the sample is 966 acres, or a total capital investment of $127,081. According to the Dominion Bureau of Statistics,[1] the average size farm in Alberta in 1966 was 706 acres, or a total capital investment of $61,734. The distribution of farms according to capital investment is shown in Figure 10.

Stratification Approach by the Alberta Department of Agriculture

The Economics Division stratified the farms in the following manner:

1. whole province
2. soil zones
3. split soil zones.

Within each zone the farms were grouped according to:

1. crop farms
2. livestock farms
3. diversified farms
4. speciality crops (irrigations).

Figure 11 illustrates the zones indicated above. The Economics Division treated the Peace River area as a separate zone because of its relative location, even though the area consists of thin black (dark grey), dark grey wooded, and grey wooded soils.

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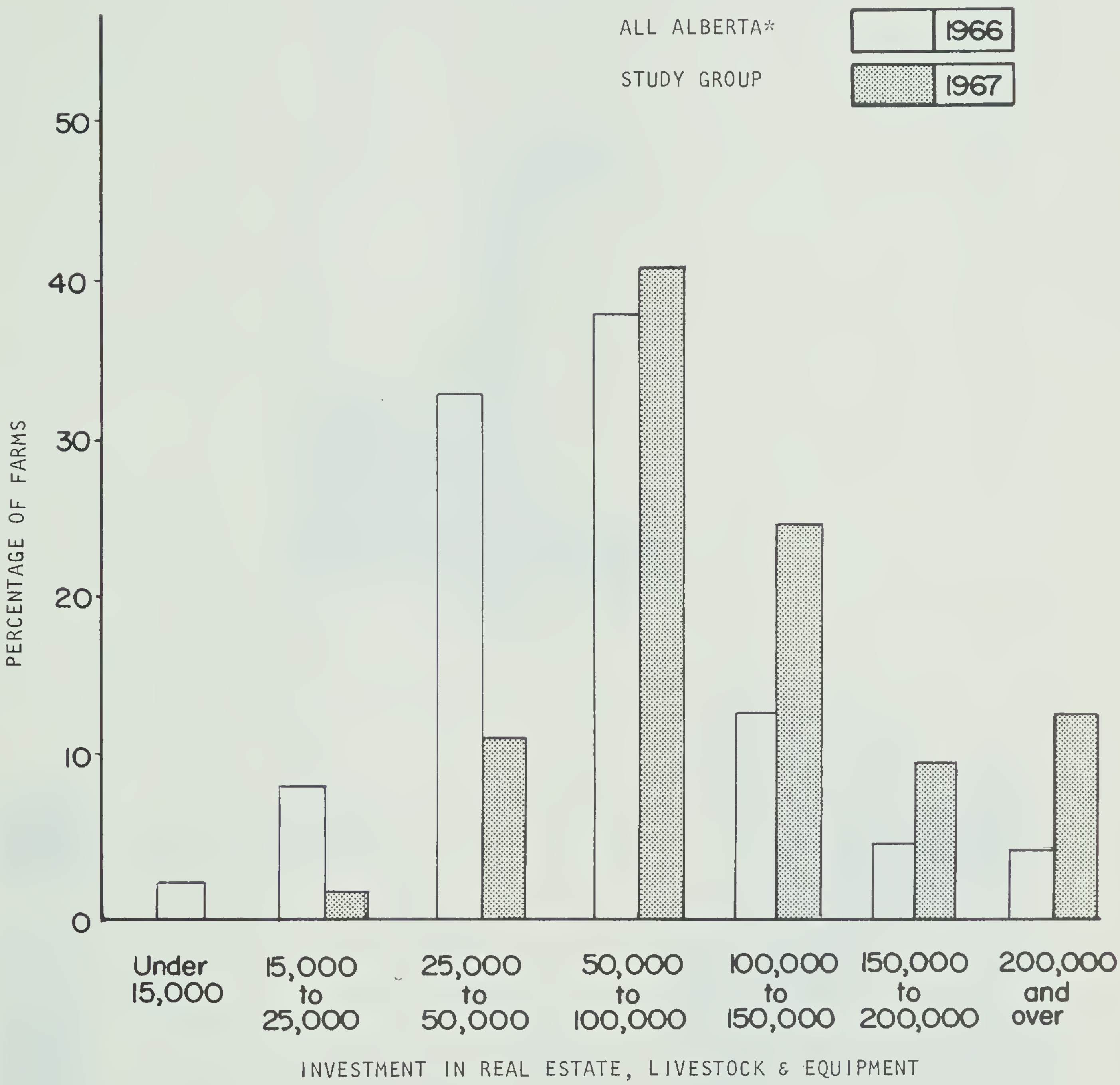
[1] Alberta Department of Agriculture, Statistics of Agriculture for Alberta 1968 and 1969, Publication No. 853-6 (Edmonton: ADA, 1971).

Figure 10

DISTRIBUTION OF FARM CAPITAL

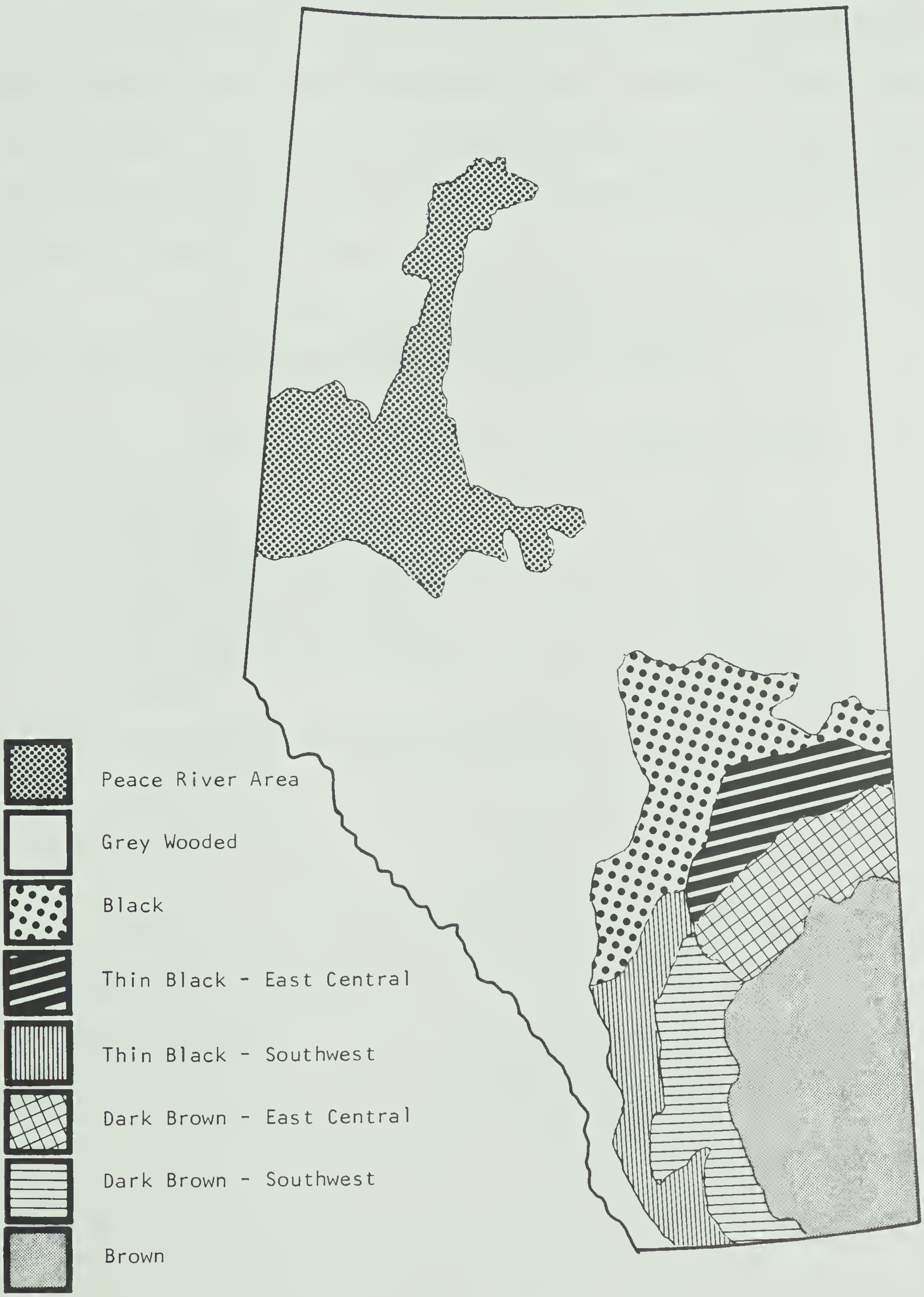


*Figures based on the 1966 Census of Canada. Only those farms classed as commercial farms used in the above comparisons.

Source: Alberta Department of Agriculture, 1967 Alberta Farm Business Analysis Report, Publication No. 819.50-41 (Edmonton: ADA, 1968).

Figure 11

THE PROVINCE OF ALBERTA, INDICATING THE SOIL ZONE STRATIFICATION USED BY THE ECONOMICS DIVISION, ALBERTA DEPARTMENT OF AGRICULTURE



A visual inspection prior to analysis was used by the Economics Division to classify the farms according to enterprise. If a particular enterprise contributed more than 50 percent to gross farm income, the unit was designated as that particular type of farm (e.g., hogs). If a farm did not have an enterprise which contributed more than 50 percent to gross farm income, the business was classified as a diversified farm.

The following indicates the number of farm records for each zone participating in the farm business analysis:

Zone		Number of Farms	
1. Brown		16	
2. Dark Brown - Southwest		31	58
3. Dark Brown - East Central		27	
4. Thin Black - Southwest		35	59
5. Thin Black - East Central		24	
6. Black		110	
7. Grey Wooded, excluding the Peace River area		51	
8. Peace River		60	
9. Whole Province	Total	354	

Within each zone the Economics Division grouped the farms according to the following:

(a) Crop farms (i) dryland

(ii) irrigated

(b) Livestock farms

(i) dairy - fluid milk
- cream and condensed

(ii) beef cattle - calves for sale
- raise calves and fatten
- straight

(iii) hog - weaners for sale
- breeding and feedlot
- feeder

(iv) poultry

(c) Diversified, and

(d) Speciality crops - irrigated (not included in analysis).

Factors Frequently Used in Farm Business Analysis Programs

There are many farm management factors which can be calculated from farm account books and used in comparative analysis. A number of these are used by the Alberta Department of Agriculture. These can be grouped under the general headings of size, use of labour, equipment and capital, crop production, and livestock production.

Size of Business

Size of the farm business can be measured in terms of acres, animal units, total gross returns or value of production, total farm investment, total man equivalents, or total productive man-work units. It is the general opinion of agricultural economists that acres of land as a measure of size is of value only when comparing similar types of farms on similar land.

An animal unit is defined as one mature cow or its equivalent in other livestock based on yearly feed intake (TDN) less manure credit.[1] It is generally thought of as 1,000 pounds of animal kept for one year for breeding purposes of 1,000 pounds of animal produced for sale. Farm business analysts use it as a common denominator in bringing all livestock to one standard unit of measure for farm management factor appraisals. Table 5 outlines the comparative units used by the Alberta Department of Agriculture. The animal unit does not give a direct indication of efficiency or intensity of production.

Total gross returns is also a measure of size. Other commonly used names for this calculation are value of production, gross operating revenue, and value of net output. This factor is equal to farm operating receipts or gross sales from agricultural products adjusted for the differences between the opening and closing inventory valuations of crops and livestock minus livestock, grain, or hay purchased. Any miscellaneous farm income which cannot be related to a crop or livestock enterprise should be added to the above calculation. The calculation of gross operating revenue or value of production can be summarized in the following way:

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[1]Alberta Department of Agriculture, Alberta Farm Management Data Manual, FMDM 109-50.

Table 5

TABLE OF ANIMAL UNITS AND PRODUCTIVE MAN-WORK UNITS

Livestock	Enterprise	No. of Animals Per A.U.	PMWU Per A.U.	Hours Per A.U.	PMWU Per Animal	Hours Per Animal
Dairy	Bulls	1	9.00	72.0	9.00	72.0
	Cows	1	9.00	72.0	9.00	72.0
	Heifers over one year	1½	3.75	30.0	2.50	20.0
	Calves	3	3.75	30.0	1.25	10.0
Beef Cow-Calf	Bulls	1	1.50	12.0	1.50	12.0
	Cows	1	1.50	12.0	1.50	12.0
	Heifers over one year	1½	1.25	10.0	.83	6.6
	Calves	3	1.25	10.0	.42	3.3
Feeder Cattle	Steers and Heifers	1000 lb. gain	1.50	12.0	.15 per cwt.	1.2 per cwt.
Hogs	Boars	2	3.50	28.0	1.75	8.0
	Brood Sows	2	3.50	28.0	1.75	8.0
	Market Hogs	1000 lb. gain	1.75	14.0	.175 per cwt.	1.4 per cwt.
Sheep	Rams	7	1.75	14.0	.80	2.0
	Ewes	7	1.75	14.0	.80	2.0
	Market Lambs	1000 lb. gain	1.75	14.0	.175 per cwt.	1.4 per cwt.
Poultry	Hens	100	18.00	144.0	.18	1.44
	Capons or Pullets raised	200	18.00	144.0	.09	.72
	Broilers	350	18.00	144.0	.05	.40
	Turkeys for laying	35	18.00	144.0	.50	4.0
	Turkey Poults or Goslings raised	70	18.00	144.0	.25	2.0

continued

Table 5 (continued)

Crop Enterprise	PMWU Per Acre	Hours Per Acre
Cereal and oilseed crops	.45	3.6
Hay, greenfeed, silage	.60	4.8
Pasture	.15	1.2
Hay, two cuts	.90	7.2
Canning corn	3.5	28.0
Canning and shelled peas	2.0	16.0
Sugar beets	6.0	48.0
Canning beets, carrots, turnips, and potatoes	6.0	48.0
Beans, cucumbers, tomatoes	9.0	72.0

Source: Alberta Department of Agriculture, Alberta Farm Management Data Manual, FMDM 109-51.

1. Crops

(-) Beginning Inventory (-) Purchases of seed grain and feed (+) Sales (+) End Inventory	Gross Returns from Crops

2. Livestock

(-) Beginning Inventory (-) Purchases of Livestock (+) Sales (+) End Inventory	Gross Returns from Livestock

3. Total Farm Production

(+) Gross Returns from Crops (+) Gross Returns from Livestock (+) Miscellaneous Sales	Total Gross Returns (or) Total Gross Operating Revenue (or) Total Value of Production

Total gross return represents the ability of a farm business to produce output and is, therefore, closely related to the number of crop acres and livestock, and their productivity. This factor does not, however, give any indication of the costs involved. Also commodity prices vary among themselves and from one year to the next, thus making total gross returns an imperfect measure of size in physical terms.

Total farm investment is a good common denominator as it reduces land, livestock, and equipment all to value terms. It may, however, measure capital efficiency rather than size. Proper evaluation of assets is required to make comparisons between farms meaningful. Total farm investment can be estimated from the average

market value of beginning and closing inventories, or the beginning, or year-end values. The former is generally considered more accurate. Some feel that these calculations should be made from the beginning inventory because the manager makes his decisions from this point. Total farm investment can be divided into the operator's farm investment and rented farm investment.

Total man equivalents is equal to the months of hired labour, family labour, and operator's labour divided by twelve. The productive man-work unit is a standard of measurement which compares the time required to accomplish certain farm tasks. In Alberta the productive man-work unit is defined as the amount of work accomplished by one man using an average amount of equipment and working at a normal pace 8 hours per day, and 26 days per month, or 208 hours per month.[1]

Labour Use

In addition to the size of business, labour efficiency is also considered important in determining net farm income. Measures of efficiency and use of labour can be in terms of total productive man-work units per man equivalent, crop acreage per man equivalent, productive animal units per man equivalent, total gross returns per man equivalent, and total value of farm labour as a percentage of total expenses.

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[1]Alberta Department of Agriculture, Alberta Farm Management Data Manual, FMDM 109-50.

Productive man-work units per man equivalent is most commonly used because it is considered a good measure of labour efficiency for all types of farms. To obtain a high value of productive man-work units per man equivalent, it is essential to have the proper organization of large or specialized enterprises (this includes farm layout), planning of work, and mechanization. A high value for this labour efficiency factor can be obtained, however, by working excessively long hours, spreading the labour and management too thinly over a large operation, or overinvestment in machinery. Above average productive man-work units per man is really of no value unless it results in higher than average crop and livestock yields; care must, therefore, be taken when interpreting the comparative analysis.

Total gross returns per man equivalent reflects, not only labour efficiency, but also yields and prices. Labour as a percentage of total expenses (fixed costs plus variable costs) is calculated in the following manner:

$$\frac{\text{Value of hired labour, family labour and the operator's basic wage allowance}}{\text{Total Farm Expenses}} \times 100.$$

Since labour and equipment can be substituted for each other these factors must be considered simultaneously when interpreting a comparative analysis. A high labour efficiency, for

[1]The operator's basic wage allowance used in the Alberta Farm Business Analysis Program in 1967 was $250 per month plus 5 percent of gross operating revenue (total gross returns) as an allowance for management, while family labour was charged at what it would have been paid if hired.

example, can be the result of a very high investment in machinery, in which case a least-cost combination has not been attained.

Equipment Use

Efficiency and use of equipment can be measured by total equipment investment and equipment investment on a per cultivated acre, per man, or per day work basis. Equipment fixed costs, equipment variable costs, or total equipment costs on a per cultivated acre, per man, or per day work basis are also used. The substitution of equipment for labour is reflected in the factor-equipment investment per man equivalent.

Capital Use

Factors calculated to measure capital use include net worth, capital ratio, percentage of capital in fixed assets, capital turnover, investment per man, capital required per dollar of gross returns, variable costs as a percentage of total costs, crop acreage per tractor, and machinery expenses per productive man-work unit. Also calculated are variable costs, fixed costs and total costs which are directly related to the size of the farm business.

Net worth of the farm business is obtained by subtracting total liabilities from the operator's total farm assets. Net worth is related to the size of the farm. The equity postion of the business is also indicated by the capital ratio, which is determined by dividing the operator's total assets by total liabilities.

Capital turnover measured in years is calculated by

dividing total farm investment by total gross returns. In terms of total gross returns, this factor states how many years it takes to recover the total farm investment. Capital turnover can also be expressed as a percentage by dividing total gross returns by total farm investment.

Variable costs as a percentage of total costs reflects, not only the intensity of farming, but also the short run flexibility of the farm operation. For these reasons it is an important factor to consider.

Variable, fixed, or total costs per dollar of gross returns express the concept of margin and, therefore, indicate the profit that is being made per unit of output. Since variable costs are those which the decision maker can control in the short run, variable costs per dollar of gross returns perhaps should be looked at more closely.

Another factor sometimes used in comparative analysis is the percentage of capital in fixed assets.[1] The Albert Department of Agriculture calculated this figure in the following manner:

$$\frac{\text{Operator's Real Estate Investment}}{\text{Total Farm Investment}} \times 100.$$

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[1]Fixed assets are those which are practically impossible to convert into cash to meet current obligations. They include land, buildings, and long-lived improvements, such as fences.

Crop and Livestock Productivity Measures

Various farm management factors are calculated to reflect the efficiency, intensity, or type of crop and livestock production. Yield per acre, gross returns from crops, gross returns from livestock, gross returns from crops per cultivated acre, gross returns from livestock per $100 of feed, productive man-work units on crops or livestock, and crop value as a percentage of total gross returns are common factors. Crop and livestock indices have also been utilized. The crop yield index as outlined by Castle and Becker[1] enables the farm manager to express the yield from all his crops as a percentage of the group average. The calculation for this yield index is illustrated in Table 6.

Table 6

CROP YIELD INDEX

	Your Farm			Standard Farm	
Crop	Acres Used	Yield per Acre	Total Production	Average Yield per Acre	Acres Required at Average Yields
Wheat	50	40 bu	2000 bu	33.3	60
Oats	30	60 bu	1800 bu	45.0	45
Hay	20	1 ton	1 ton	2.0	10

Total Acres 100 = A B = 115

Crop Yield Index = $\frac{B}{A}$ $\frac{115}{100}$ = 115%

[1] Castle and Becker, op. cit., p. 107.

In this example, comparative analysis has revealed that the individual farm is above average with respect to general crop yields. It should also be noted that the individual hay yield is only one-half the group average, so there is still room for improvement. A livestock index can be developed in a similar manner.

The crop yield index described by Blagburn[1] incorporates crop prices into the calculation:

$$\text{Crop Yield Index} = \frac{\text{Total value of crop production on the individual farm}}{\text{Standard value of production}}$$

The standard value of production is calculated by multiplying the acres in each crop by the average yield for the district and the value per unit. These calculations indicate what the total value of crops produced on the individual farm would have been if average yields and grades for the district had been obtained. A livestock yield index which utilizes prices can be calculated the same way.

The "system index" developed by Blagburn[2] is an intensity index measuring the relative value of production of the enterprises on an individual farm at average yields as compared to the average of the group on the same acreage. When applied to crops only, this index is more commonly known as a crop intensity index:

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[1] C. H. Blagburn, A Simple System of Economic Analysis of a Farm Business (University of Reading, Department of Agricultural Economics, 1957), pp. 8-9.

[2] Ibid., p. 7.

$$\text{Crop Intensity Index} = \frac{\text{Standard value of crops per cultivated acre for the individual farm using group average yields}}{\text{Standard value of crops per cultivated acre from the group}}$$

Not only does the crop intensity index show whether the manger is raising higher-valued or lowered-valued crops than average, but it also reflects the percentage of cultivated land that is left in fallow each year. An index below the group average would indicate below average rotation intensity and/or crops of less value in the marketplace.

Crop and livestock indices were not used by the Alberta Department of Agriculture in 1967, and for this reason they are not included in this study.

From the many farm management factors which can be used in comparative analysis, it is evident that one of several factors may be chosen to measure the same characteristic. What is the most relevant measure of size, for example, among the many size factors which can be calculated? There are also many examples where management factors are closely related to or interact with each other, such as size in terms of acres and machinery investment. As pointed out previously, labour and equipment efficiency factors must be studied simultaneously in comparative analysis because labour and equipment can substitute for each other. A high labour efficiency may be due to overinvestment in machinery.

The interpretation of comparative analysis requires careful study because of the many complexities and interactions which exist among the many management factors calculated. It was, therefore, the primary objective of this study to identify those farm management factors which make a significant contribution to farm profits. By eliminating many unimportant factors or adding new important ones, the task of the entrepreneur in comparative analysis will be made easier. A secondary objective was to construct an equation for predicting farm profits using the data from a farm business analysis. Again the interaction of management factors poses a real problem, for closely related factors should not be used in the same equation. The approach to these problems is outlined in Chapter Five.

CHAPTER V

METHODOLOGY

Model

The statistical tools used in this study were multiple correlation analysis and stepwise regression analysis. An alternative approach was factor analysis. Robert A. Pearse has stated:

> ...apparently there is no antagonism or conflict in the results obtained using multiple regression and factor analysis. In fact, the factor analysis would assist in deducting the variable which would be worth applying in a regressions.[1]

Because the writer is more familiar with the former approach, regression-correlation analysis was used in this research.

Regression analysis refers to the techniques for the derivation of an equation by which one of the variables, the "dependent variable," may be estimated from the other variables, the "independent variables." Correlation analysis deals with the measurement of the closeness of the relationships which are described in the regression equation.[2]

The general form of the linear functional relationship which exists among variables can be expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 Y_2 + \ . \ . \ . \ . \ + \beta n X n,$$

where Y, the dependent variable is a linear function of the independent variables X_1 through Xn. β_0 represents the intercept term on

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[1]Pearse, op. cit., p. 71.

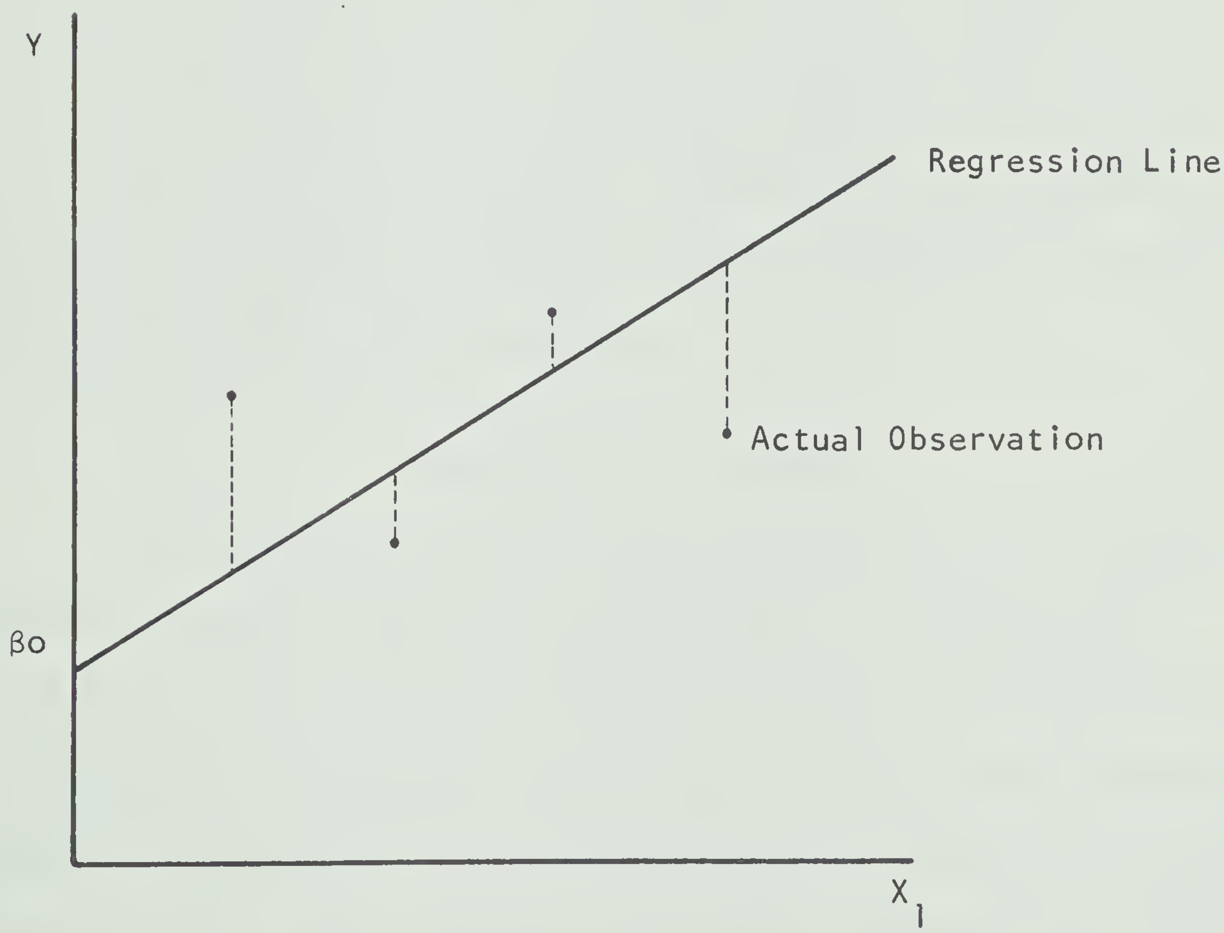
[2]Samuel B. Richmond, Statistical Analysis (New York: The Ronald Press Company, 1964), p. 424.

the Y axis. $\beta_1 \ldots \beta n$ represents the coefficients of the respective independent variables, $X_1 \ldots Xn$.

The equation is developed by a technique known as "least squares." Figure 12 is presented to illustrate this procedure for a simple two variable case, $Y = \beta_0 + \beta_1 X_1$. From the scatter diagram

Figure 12

ILLUSTRATION OF REGRESSION LINE



of actual observations involving X_1 and Y, a regression line is fitted whereby the summation of the squared vertical distances between the actual observations and the prediction line is minimized. The result is a prediction equation to estimate the dependent variable Y, (for example, returns to labour and management) from any value of the independent variable X_1 (for example, gross returns from crops per crop acre).

If only two variables are involved, we have a case of simple correlation or simple regression, depending on which we are doing. With three or more variables, the appropriate terminology is multiple correlation, measured by the multiple coefficient of correlation (R), or multiple regression, measured by the multiple coefficient of determination (R^2). The standard error measures the variability of the observed points about the regression line calculated by the lease squares technique.

Stratification of Farms

The approach to the problem was dictated in part by the extent of available data. In the beginning, it was considered desirable to stratify the available farms according to enterprises within each soil zone or split soil zone to obtain a more homogeneous groups of farms without each subsample becoming too small for statistical analysis. This could not be achieved completely because of the small number of farms. The total number of farms participating in the program for the brown soil zone, for example, was only sixteen. The number of farms for each livestock enterprise classification

within a soil zone was also very small, and, therefore, for the purposes of this study all such operations were called livestock farms with no further subdivision.

The 354 farms were, consequently, stratified in the following ways:

Enterprise Stratification		Number of Farms
Stratum 1	Crop farms	98
Stratum 2	Diversified farms	147
Stratum 3	Livestock farms	109
	Total	354

This stratification is based on enterprise classification by the Economics Division, Alberta Department of Agriculture as outlined previously. This approach has two weaknesses. The farms of one stratum are scattered throughout the province and thus represent production under varying soil and weather conditions. Also classification of a particular farm is highly dependent on productivity of the livestock and crop enterprise. For example, a bad crop year for a typical diversified farm could be misleading in that it might be classed as a livestock farm. An alternative would be to use a stratification based on the ratio of animal units to crop acres. An arbitrary range would be required to obtain a suitable stratification.

Soil Zone Stratification

Grouping the farms according to soil zones gives the following distribution:

Zone	Number of Farms
Brown	16
Dark Brown	58
Black	110
Thin Black	59
Grey Wooded, excluding the Peace River area	51
Peace River area	60
Total	354

This approach has the disadvantage of including all types of farms in the same group or soil zone.

The diverse nature of the farms poses a real problem in the stratification of farms for comparative analysis. The various different types of enterprises producing under varying soil and weather conditions, in addition to such considerations as distance from the market, accounts for large variations in the data obtained. For this reason the criterion for grouping the farms for comparative analysis could be extremely important if meaningful conclusions are to be obtained. The individual farmer is comparing his business to group averages which are solely dependent on the method of stratification. If the farms are too heterogeneous in nature, it is conceivable that the magnitude of the variation of specific management factors is so large that the factor is not significantly related to farm profits, and thus comparative analysis is of no value.

Measures of Profit

Net farm income represents the return to the manager for his labour, management, and capital (equity) investment. It is the first step in the analysis of the completed farm record. In addition to being of sufficient magnitude to give the farmer and his family a comfortable living, it should also give a reasonable return on the total farm investment in the long run. Net farm income can be computed in the following manner:

Total Operating Receipts ± net change in inventory - value of livestock used in the home - seed purchased, grain, and supplies purchased for resale - feed and livestock purchased	Gross profit or value of production
	minus
Total current farm expenses ± change in inventory of supplies - unpaid family labour	Total operating expenses
	minus
Depreciation on farm home (farm share) Depreciation on buildings Depreciation on machinery	Total depreciation
	minus
	Interest paid
	= Net Farm Income.

Assuming that the goal of the farm manager is to maximize profits under existing constraints, a measure of financial success is required. Residual profit figures, rather than net farm income, are used in making comparisons among farms because they tend to reduce farms to the same basis, (the disadvantages of net farm income as a measure of profit were pointed out on page 18). Residual returns often used are management returns, operator's labour and management return, and percentage earned on investment.

The residual method used in farm business analysis to calculate a measure of profit is based on Euler's theorem.[1] It states that if each factor of production (e.g., land, labour, capital, and management) is imputed its marginal value product, the total value product will be exactly exhausted when constant returns to scale prevail. In other words, a summation of the values of the marginal (added) outputs arising from a marginal unit of each factor of production will equal exactly the value of the total output when the elasticity of production is one. Problems arise, however, in applying Euler's theorem. First, because the law of diminishing returns usually holds true in agricultural production and stage two is the relevant area of production (Figure 5), managers seldom operate at the precise point where the elasticity of production is equal to one (beginning of stage two).

The second problem which arises with the residual method of

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[1]Heady, op. cit., p. 407.

calculating measures of profit is the computation of correct market prices corresponding to the marginal value product for each factor of production. Incorrect values will result in residuals which cannot be allocated to any particular resource with justification. The calculation of percent return on total farm investment, for example, involves subtacting the value of the farmer's labour and management from net farm income to which interest payments have been added. As every farmer has a different earning capacity in another job and management abilities vary, caution must be used in assigning values to these factors of production, or large errors can occur in evaluating the residual return to capital investment.

The operator's return for labour and mangement was chosen as the residual profit figure because it tends to reduce farms to the same basis and avoids the problem of assigning labour and management values to each farm. It was calculated in a manner similar to that outlined by Castle and Becker.[1] Net farm income was reduced by interest payments on loans and mortgages, plus the approximate return which could be realized (7 percent) if the operator's equity farm investment were placed in Canada Savings Bonds. Rented farm investment is not included in this calculation because the rental (crop share or cash) approximates the opportunity cost of capital. Total farm investment must be considered, however, when evaluating the factors which affect farm profit because of the contribution which rented assets (e.g., land) make to net farm income.

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[1]Castle and Becker, op. cit., p. 90.

Farm Management Factors Used in this Study

The following factors were used as the independent variables (X's) in a multiple regression-correlation analysis:

1. Measures of Size

   - total farm acres
   - total cultivated acres
   - total crop acres
   - total farm investment
   - total man equivalents
   - total animal units
   - total productive man-work units
   - total gross returns

2. Labour Use

   - productive man-work units per man equivalent
   - gross returns per man equivalent
   - labour as a percentage of total expenses
   - productive man-work units as a percentage of total farm investment
   - productive man-work units per cultivated acre
   - productive man-work units on crops
   - productive man-work units on livestock

3. Equipment Use

   - equipment investment
   - equipment investment per man equivalent
   - equipment investment per cultivated acre
   - depreciation of equipment
   - equipment fixed costs
   - equipment fixed costs per man equivalent
   - equipment fixed costs per cultivated acre
   - equipment variable costs
   - equipment variable costs per man equivalent
   - equipment variable costs per cultivated acre
   - total equipment costs
   - total equipment costs per man equivalent
   - total equipment costs per cultivated acre

4. Capital Use

   - net worth
   - capital ratio
   - capital turnover
   - variable costs as a percentage of total costs
   - percentage of capital in fixed costs
   - fixed costs

- variable costs
- total costs
- fixed costs per cultivated acre
- variable costs per cultivated acre
- fixed costs per dollar of gross returns
- variable costs per dollar of gross returns
- total costs per dollar of gross returns
- real estate investment
- real estate investment per cultivated acre
- real estate investment per man equivalent
- investment in feed and supplies
- livestock investment
- livestock investment per cultivated acre
- livestock investment per man equivalent
- total farm investment per cultivated acre
- total farm investment per man equivalent

5. Crop Productivity

    - gross returns from crops
    - gross returns from crops per crop acre
    - gross returns from crops per cultivated acre

6. Livestock Productivity

    - gross returns from livestock
    - gross returns from livestock per animal unit
    - gross returns from livestock per $100 feed

7. Other

    - percentage of cultivated land in summer fallow
    - a profit or success index

Because the Alberta Department of Agriculture did not calculate a crop yield index, crop intensity index, or livestock yield index, the conventional indices were not included in this study.

A profit or success index suggested by Petersen[1] is calculated in the following manner:

$$\text{Success Index} = \frac{\text{Value of Production}}{\text{Variable Costs}} \times \frac{\text{Value of Production}}{\text{Total Farm Investment}}$$

As stated on page 76, variable, fixed, or total costs per dollar of gross returns express the concept of margin and, therefore, indicate the profit that is being made per unit of output. Variable costs are those which the decision maker can control on a year to year basis, so the ratio of production to variable costs is used in the success index. As profit is a function of margin and volume, it seems logical to utilize capital turnover as the volume ingredient in this index. A high output relative to variable costs and total farm investment should give a high index and high profits or success. Similarly, judicious decisions in variable costs or capital investment would also raise the success index. This approach leads to the possibility of isolating the areas of weakness in the farm operation very quickly.

Approach

Simple correlations, averages, and standard deviations were obtained for all variables of each stratum for the two methods of stratification outlined previously. The identification of those factors significantly related to farm profits was done utilizing the

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[1] T. A. Petersen, Associate Professor, Department of Agricultural Economics and Rural Sociology, University of Alberta, Interview.

two variable linear regression models of the form, $Y = \beta_0 + \beta nXn$. Those factors closely related to the measure of profit (operator's return to labour and management) were determined to be statistically significant by means of a statistical tool known as the Student's t Test. The level at which management factors (X's) were considered significantly related to profit was determined by comparing the calculated t ratio to a set of standard t values with the probability of coming to a correct conclusion 95 percent of the time (95 percent confidence level or 5 percent level of significance). Regression equations, for the enterprise classification, were constructed with factors or independent variables (X's) having simple correlations with each other to the extent of less than approximately 20 percent to minimize the effects of multicollinearity. Two factors with a high correlation were included in the same equation only when common sense would suggest a low relationship between them and the high correlation could thus be assumed to have occurred by chance. Some of these same equations were applied to the soil zone stratification of sample farms.

CHAPTER VI

RESULTS

The primary objective of this study was to identify those efficiency factors obtained from the farm account books that have a significant relationship to farm profits measured as returns to labour and management. These factors were determined by utilizing the two variable linear regression model of the form, $Y = \beta_0 + \beta nXn$. The Students t distribution was used to test for statistically significant results using the .05 level of significance. The farm management factors selected from those studied are presented in Table 8 for enterprise and soil zone stratifications.

The second objective of this study was to develop one or more prediction equation(s) for estimating the magnitude of returns to labour and management from easily available data. These equations are presented in Table 10 for enterprise classification and Table 11 for soil zone classification of farms.

Multicollinearity[1]

Preliminary results based on simple correlations supported the hypothesis that many of the farm management factors used in

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[1]Multicollinearity is the name given to the problem arising when some or all of the explanatory variables in a relation are so highly correlated one with another that it becomes difficult to disentangle their separate influences and obtain a reasonably precise estimate of their relative effects.

comparative analysis are closely related to each other. The high correlation of explanatory or independent variables, which leads to the problem of multicollinearity, makes it difficult to determine the exact effect that each farm management factor used in a prediction equation has on the residual profit measure. Thus because it lowers the statistical problems created by multicollinearity, a two variable linear model was used to select the important farm management factors. Factor analysis also attempts to deal with multicollinearity by finding another, but smaller, set of independent variables (or factors) that explain the original set of independent variables (X's). As outlined on page 82, similar results can be obtained by using either regression and correlation analysis or factor analysis.

To develop a prediction equation, the close relationship that often exists between two factors (independent variables) cannot be ignored. This accounts for the many combinations of variables tried in searching for useful prediction equations. These equations will be discussed later.

Data Variability

In addition to multicollinearity, extreme data variability was a problem. For example, the average gross returns from livestock per animal unit on the livestock farms was \$229.83, with a standard deviation of \$126.28. The average total farm investment on these farms was \$141,734, with a standard deviation of \$112,233. The large variation in total farm investment meant that this measure of size was inconsequential as an explanatory variable on livestock farms.

The same phenomenon holds for many other variables, resulting in low confidence levels.

One source of variation arises from individual farmers evaluating their own real estate, livestock, equipment, feed, seed, and supplies. The same asset would probably be valued differently by many farm managers.

A second source of variation involves the location of land. The land location relative to a population center and the demand for land in a particular area will lead to variations in the price of land areas with the same capability rating. Market prices are, therefore, not necessarily related to land productivity.

A third source of variation arises from the diverse nature (heterogeneity) of the sample farms, thus emphasizing the importance of stratification. For example, livestock farms include various types of dairy and beef cattle, hog, and poultry enterprises with production taking place throughout the province under different production processes and soil and weather conditions. On the other hand, stratification on the basis of soil zones includes different enterprises (livestock, diversified, and grain) within the same soil zone so that the problems associated with heterogeneity still exist. Even within a soil zone, gross returns per animal unit or per $100 feed can vary from one type of livestock enterprise to another. For example, the value of production per animal unit was $363.42 for dairy enterprises studied in the black soil zone, as compared to $162.31 per animal

unit for hog enterprises.[1] Similarly, feed costs as a percentage of total costs vary considerably from one type of livestock enterprise to another. For the farms mentioned above, feed costs comprised 47.6 percent of total costs for dairy enterprises, 63.3 percent of total costs for hog enterprises. The need for caution in comparative analysis is illustrated in Table 7 where the comparison of different livestock enterprises through the use of group averages may lead to erroneous conclusions.

Table 7

HYPOTHETICAL EXAMPLE OF LIVESTOCK FARMS USED IN COMPARATIVE ANALYSIS

Type of Livestock Enterprise	Number of Farms		Gross Returns from Livestock per Animal Unit
Dairy	1		$ 300
Hogs	1		150
Beef Feeder	1		250
Cow-calf	1		100
Total	4		$ 800
Livestock group average		$\frac{800}{4}$ =	$ 200

The dairy farmer in this example is well above the group average for the livestock farms considered. However, his gross returns from

[1]Alberta Department of Agriculture, <u>1967 Farm Business Summary, Black Soil Zone - Central Alberta</u>, Publication No. 819.50-47 (Edmonton: ADA, 1968).

livestock per animal unit ($300) may be low when he compares his dairy operation to other dairy farms. As stated previously, the average gross returns from livestock per animal unit was $363.42 for dairy enterprises in the black soil zone.

A fifth source of variation comes from possible accounting errors. The farm manager may, for example, overlook 1000 bushels of grain in storage or underestimate the amount of tractor fuel remaining at the year's end. All of these errors on the part of the manager are accumulated in total gross returns and operating expenses. Although the accumulated errors may seem small relative to the magnitude of total gross returns or operating expenses, the impact may be substantial on a residual profit measure, such as the return to labour and management. For example, an error of $1,000 in total gross returns of $20,000 is only 5 percent, but with an operator's return to labour and management of $5,000, the error is actually 20 percent. Even an elaborate accounting system (such as Canfarm) only partially solves this problem by making accurate calculations and organizing the data submitted by the entrepreneur. While such a system provides built-in cross-checks for accounting precision, undetectable errors in inventory quantities, values, and depreciation, plus errors in allocation among enterprises, cannot be accurately checked and depend solely on the farmer's judgement. Thus a residual profit measure, such as operator's labour earnings, which is used as the dependent variable in this analysis, can be subject to large observational error leading to increased variability and reduced confidence.

Despite these obstacles, the data were analyzed and assessed using the two variable model, $Y = \beta_0 + \beta nXn$. The results portrayed are based on the two types of stratification outlined on page 84. These were (a) stratification by enterprise (livestock, diversified, and crop farms) and (b) stratification by soil zones of the province.

Enterprise Stratification

The selected farm management factors for the enterprise stratification are presented in Table 8. Those factors which appeared to make a significant contribution to the operator's return to labour and management (using the .05 level of significance) are designated by a * sign. From the many casual factors studied, some were eliminated on the basis of common sense, supported by statistical results that suggested a high correlation among them. This applied particularly to factors related to measures of size. The following farm management factors are not included in Table 8:

1. Total farm acres
2. Total crop acres
3. Productive man-work units on crops
4. Productive man-work units on livestock
5. Equipment investment
6. Depreciation of equipment
7. Equipment fixed costs
8. Equipment variable costs
9. Total equipment costs
10. Fixed costs
11. Variable costs
12. Total costs
13. Investment in feed and supplies
14. Livestock investment
15. Real estate investment
16. Gross returns from crops
17. Gross returns from livestock

Table 8

FARM MANAGEMENT FACTORS FOR FARMS STRATIFIED BY ENTERPRISE AND SOIL ZONE, INDICATING THOSE FACTORS WHICH ARE SIGNIFICANTLY[1] RELATED TO THE OPERATOR'S RETURN TO LABOUR AND MANAGEMENT[2]

FARM MANAGEMENT FACTORS	STRATIFICATION BY ENTERPRISE			STRATIFICATION BY SOIL ZONE					
	LIVESTOCK	DIVERSIFIED	GRAIN	BROWN	DARK BROWN	BLACK	THIN BLACK	GREY WOODED	PEACE RIVER
SIZE									
TOTAL CULTIVATED ACRES (AC.)	534	549	929*	847*	1,012	553	672	389*	624* (a)
TOTAL FARM INVESTMENT ($)	141,734	104,415	144,799	137,990	165,425	131,558*	171,831* (a)	73,725*	80,275* (a)
TOTAL MAN EQUIVALENTS	1.7*	1.5	1.4	1.6	1.6	1.6*	1.6* (a)	1.5*	1.3
TOTAL ANIMAL UNITS	123	71	32	87	75	91*	102* (a)	73*	26
TOTAL PRODUCTIVE MAN-WORK UNITS	570*	396	370	449*	479	463*	517	409*	323
TOTAL GROSS RETURNS ($)	27,052*	17,608*	23,723*	25,803*	28,519*	24,902*	27,156	13,836*	12,466
LABOUR USE									
PRODUCTIVE MAN-WORK UNITS PER MAN EQUIVALENT	342	264	259	284	307	293*	302	270*	254
GROSS RETURNS PER MAN EQUIVALENT ($)	16,002*	11,565*	16,228*	16,236*	18,136*	15,478*	16,531*	8,762*	9,972
LABOUR AS A PERCENTAGE OF TOTAL EXPENSES (%)	16.6	20.8	17.8	17.1	14.5	16.7	15.4	26.0	23.8* (c)
PRODUCTIVE MAN-WORK UNITS AS A PERCENTAGE (%) OF TOTAL FARM INVESTMENT	.005	.004	.003	.003	.003	.004	.003	.006	.004*
PRODUCTIVE MAN-WORK UNITS PER CULTIVATED ACRE	1.22*	.84	.43	.74	.60	.92	.92	1.18	.61
EQUIPMENT USE									
EQUIPMENT INVESTMENT PER MAN EQUIVALENT (%)	11,932	11,989	16,849	12,638	16,533	13,570	13,540	8,975	13,398* (b)
EQUIPMENT INVESTMENT PER CULTIVATED ACRE ($)	48.27	34.02	27.30	33.14	26.17	49.41	35.35	35.42	26.19
EQUIPMENT FIXED COSTS PER MAN EQUIVALENT ($)	2,278	2,272	3,310	2,451	3,272	2,576	2,631	1,708	2,535* (b)
EQUIPMENT FIXED COSTS PER CULTIVATED ACRE ($)	9.35	6.40	5.38	6.41	5.15	9.70	6.74	6.39	4.92
EQUIPMENT VARIABLE COSTS PER MAN EQUIVALENT ($)	1,355	1,365* (b)	1,909	1,710	1,953	1,403	1,661	1,054	1,478
EQUIPMENT VARIABLE COSTS PER CULTIVATED ACRE ($)	7.18	4.01	3.17	4.88	3.30	6.93	4.29	4.14	3.13
TOTAL EQUIPMENT COSTS PER MAN EQUIVALENT	3,634	3,622	5,221	4,161	5,227	3,979	4,255	2,762	4,013
TOTAL EQUIPMENT COSTS PER CULTIVATED ACRE ($)	16.53	10.34	8.55	11.29	8.45	16.64	10.92	10.42	8.05
CAPITAL USE									
NET WORTH ($)	112,967	83,468	117,704	132,109* (c)	130,072	102,493	138,444* (b)	59,394* (c)	66,481* (b)
CAPITAL RATIO[3]	5,327	516	4,838	31	4,052	2,233	9,573	1,569	78* (b)
CAPITAL TURNOVER (YEARS)	6.0*	6.5*	6.6*	5.7*	6.4*	6.0*	6.9*	6.0*	6.9*
VARIABLE COSTS AS A PERCENTAGE OF TOTAL COSTS (%)	58.2	48.8	43.3	48.9	55.1	54.2	53.0	47.5	37.8
PERCENTAGE OF CAPITAL IN FIXED ASSETS (%)	49.2* (b)	54.4* (b)	53.2* (b)	51.6	47.7	50.4* (b)	52.4* (b)	53.3* (b)	60.3
FIXED COSTS PER CULTIVATED ACRE ($)	29.43	24.47	17.43	25.84	17.64	27.62	27.36	26.98	17.49* (c)
VARIABLE COSTS PER CULTIVATED ACRE ($)	51.89	26.81	16.04	28.16	28.45	40.50* (c)	43.45	25.70	12.32* (c)
REAL ESTATE INVESTMENT PER CULTIVATED ACRE ($)	152.42	118.14	105.90	127.10* (b)	111.74	141.23	164.79* (b)	108.31	84.38
REAL ESTATE INVESTMENT PER MAN EQUIVALENT ($)	46,626	42,840	64,647	52,044	65,571	49,372	63,682	26,754	42,111* (b)
LIVESTOCK INVESTMENT PER CULTIVATED ACRE ($)	51.44	27.48	8.80	30.37	23.50	34.64	42.81	33.60	10.16
LIVESTOCK INVESTMENT PER MAN EQUIVALENT ($)	16,247	8,890	4,854	10,741	10,892	11,492	13,935	9,092	3,331
TOTAL FARM INVESTMENT PER CULTIVATED ACRE ($)	272.40	197.78	163.43	215.26	182.62	243.28	276.04* (b)	191.64	132.05
TOTAL FARM INVESTMENT PER MAN EQUIVALENT ($)	83,263	70,459	99,790	87,333	106,932	83,759	102,649	48,408	64,577* (b)
CROP PRODUCTIVITY									
GROSS RETURNS FROM CROPS PER CULTIVATED ACRE ($)	25.51*	23.20*	23.93*	32.69	22.32*	28.75*	26.69	20.22*	15.80*
LIVESTOCK PRODUCTIVITY									
GROSS RETURNS FROM LIVESTOCK PER ANIMAL UNIT ($)	229.83*	154.18*	110.43	89.70	134.46	199.81*	185.45*	160.79	136.39
GROSS RETURNS FROM LIVESTOCK PER $100 FEED ($)	182.46*	158.73*	118.38	193.38	156.07	159.30	178.52*	152.25	114.27
OTHER									
PERCENTAGE OF CULTIVATED LAND IN SUMMER FALLOW (%)	8	16	26	18	30	12	17	7	17
SUCCESS INDEX	.31*	.27*	.37*	.41*	.28*	.30*	.30*	.31*	.34*
RETURN TO LABOUR AND MANAGEMENT ($)	1,354	-599	218	2,217	28	1,416	-356	292	-1,766

1. FARM MANAGEMENT FACTORS SIGNIFICANT AT THE .05 LEVEL OF SIGNIFICANCE ARE DESIGNATED BY *.

2. THE NUMBERS SHOWN ARE GROUP AVERAGES OR MEANS.

3. LARGE AVERAGE VALUES FOR CAPITAL RATIO WERE OBTAINED BECAUSE SOME FARMS HAD NO LIABILITIES. CAPITAL RATIO = $\frac{\text{TOTAL ASSETS}}{\text{TOTAL LIABILITIES}}$

a UNEXPECTED NEGATIVE RELATIONSHIP WITH OPERATOR'S RETURN TO LABOUR AND MANAGEMENT.

b NEGATIVE RELATIONSHIP WITH OPERATOR'S RETURN TO LABOUR AND MANAGEMENT.

c POSITIVE RELATIONSHIP WITH OPERATOR'S RETURN TO LABOUR AND MANAGEMENT.

Also, variable, fixed, or total costs per dollar of gross returns were not selected because they express the concept of margin and, therefore, indicate the profit that is being made per unit of output. As was expected, they are significantly and consistently related to farm profits for the enterprise and soil zone groups.

The important farm management factors from the enterprise grouping emphasize the ability of the farm to produce output in terms of dollars. For example, total gross returns, gross returns per man equivalent, gross returns from crops per cultivated acre, and capital turnover[1] were significantly related to the return to labour and management for livestock, diversified, and crop farms. Increased output is brought about by one or more of several methods: larger size; more intensive farming; utilizing higher productive land, livestock, and crops; and producing output of higher value. Not all farm management factors studied, however, which are associated with the methods of increasing output were found to be significantly related to farm profits.

Total gross returns was the only measure of size found to be important for all three enterprise groups. In addition, total man equivalents and total productive man-work units were valuable measures of size for livestock farms. As expected, total cultivated acres was significantly related to farm profits on grain farms. However, total animal units were not important on livestock farms.

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[1]Capital turnover, measured in years, is calculated by dividing total farm investment by total gross returns.

This unexpected result may arise from the calculation of animal units, which brings all types of livestock to one common denominator.[1] As shown in Table 5, 1 cow, 2 brood sows, 7 ewes, 100 hens, or 350 broilers are equal to one animal unit. Because these standards may be unrealistic in a relative sense, as well as being difficult to calculate accurately from available information, different measures of size for livestock farms should be sought.

Another method for producing additional output is to farm more intensively. This involves utilizing more variable inputs such as fertilizer and feed on the inputs of land and livestock respectively. This is the same as moving up the production function illustrated in Figure 5. The farm management factor directly measuring the intensity of farming, namely variable costs as a percentage of total costs, was not related significantly to farm profits. This is an unexpected result, for it is assumed that as the manager farms more intensively, the greater is his return to labour and management. The failure of this farm management factor to be consistent with economic theory could result from the sources of data variability outlined previously. For example, high variable costs relative to total costs may be caused by such items as old and obsolete equipment or buildings with high repair and maintenance costs, rather than by intensifying inputs such as fertilizer or livestock. Furthermore, hired labour, which was treated as a variable cost by the Alberta Department of

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[1]An animal unit is defined as one mature cow or its equivalent in other livestock based on yearly feed intake less manure credit.

Agriculture, may be underemployed or poorly utilized. Thus large interpretational errors may occur when using variable costs as a percentage of total costs to represent farming intensity.

Important farm management factors reflecting intensity, inherent productive capacity, and prices are gross returns from crops per cultivated acre, gross returns from livestock per animal unit, and gross returns from livestock per $100 feed. In addition to reflecting yields and product prices, gross returns from crops per cultivated acre can also be influenced by the percentage of cultivated land in fallow, but this factor was not significant for the farms studied.

Despite the variation that can exist between a particular farm management factor and the operator's return to labour and management, the livestock efficiency factors were important on livestock and diversified farms. The simple correlation of gross returns from livestock per animal unit and returns to labour and management on livestock farms was .41.[1] The actual farm observations for this stratification, plotted in Figure 13, illustrate the trend in profit as gross returns from livestock per animal unit increases on livestock farms. The regression (prediction) line fitted to these observations is also shown.

Gross returns from crops per cultivated acre was significant for all three enterprise classifications, whereas livestock

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[1] Perfect correlation, represented by 1.00, exists when all values satisfy an equation exactly.

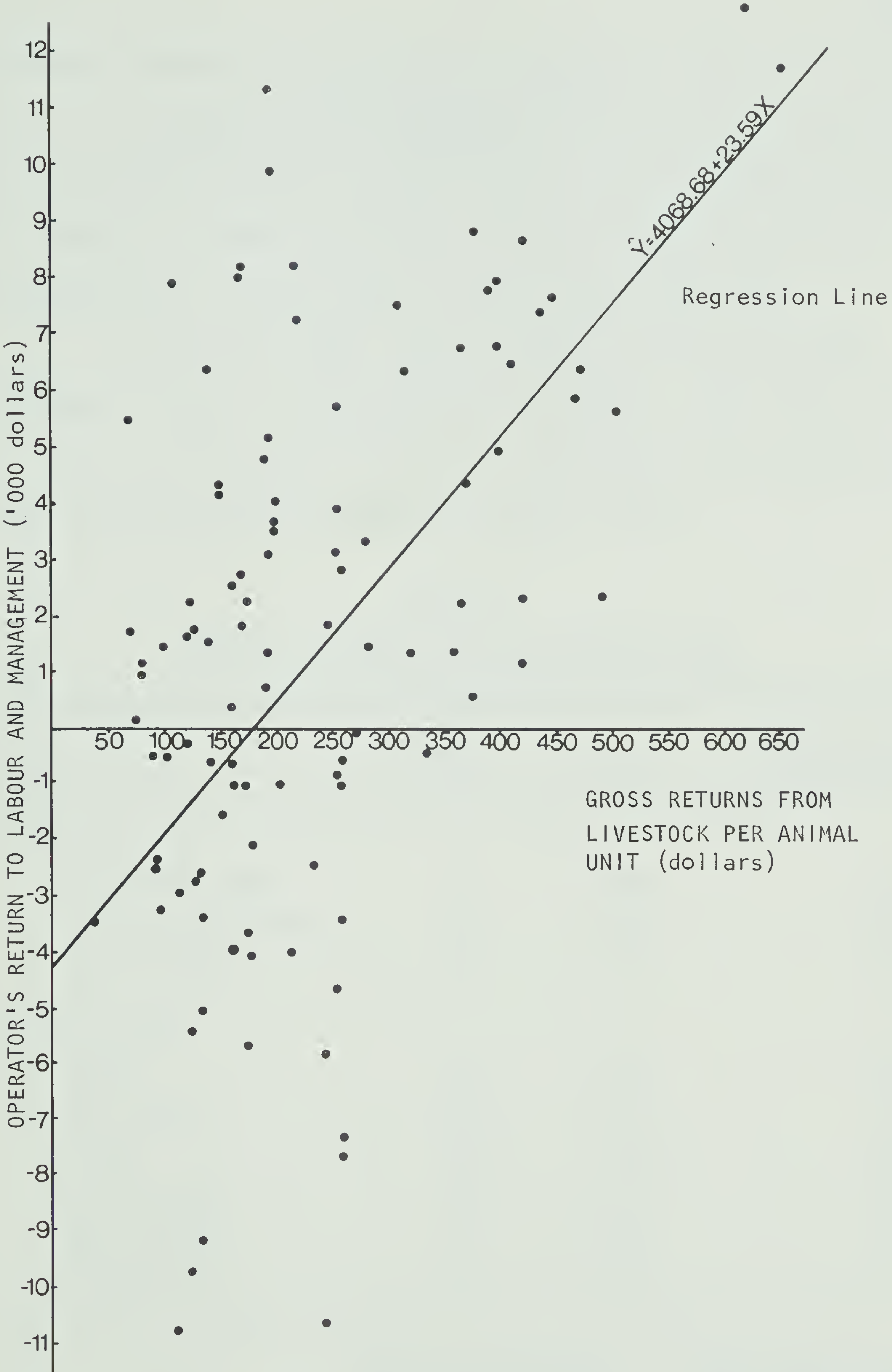

Figure 13

THE RELATIONSHIP OF GROSS RETURNS FROM LIVESTOCK
PER ANIMAL UNIT AND FARM PROFIT FOR THE LIVESTOCK FARMS STUDIED

efficiency factors were important on livestock and diversified farms only. As the important farm management factors are not the same for each enterprise stratum, the results of this stratification point out the necessity of comparing farms of similar enterprise type and of using efficiency factors unique to a particular enterprise.

The success index, which was added to the list of farm management factors, was important for all groups. The results for this index are presented in Table 9. There appear to be potential benefits from further development of such an index.

Table 9

SUMMARY OF RESULTS FOR THE SUCCESS INDEX

Stratification	Mean	T ratio	Coefficient of Determination
A. Enterprises			
Livestock farms	.31	5.60	.23
Diversified farms	.27	7.75	.29
Grain farms	.37	7.14	.35
B. Soil Zones			
Brown	.41	4.34	.57
Dark Brown	.28	4.64	.28
Black	.30	5.70	.23
Think Black	.30	4.70	.28
Grey Wooded	.31	5.06	.34
Peace River	.34	7.63	.50

[1] Success index = $\frac{\text{Total gross returns}}{\text{Variable costs}} \times \frac{\text{Total gross returns}}{\text{Total farm investment}}$

The success index was discussed on page 91.

Soil Zone Stratification

Several inconsistencies appeared in the results when all types of sample farms were stratified according to soil zones. Some of the inconsistencies from one soil group to another may result from the predominance of a specific enterprise (for example, livestock farms) within the soil zone. The farms included in the black soil zone of this study, for example, consisted of 50 livestock farms, 48 diversified farms, and 12 grain farms. As expected the significant factors from the black soil group included gross returns from livestock per animal unit and gross returns from livestock per $100 feed. But because the Peace River classification included predominantly grain farms, the livestock efficiency factors were not important, Similarly, the number of animal units was significantly related to profits for the black soil zone, but not for the Peace River area.

A second inconsistency involved measures of size. Significant measures of size had a positive effect on farm profits in all soil zones except the thin black and Peace River strata. As shown in Table 8, the return to labour and management decreased on the Peace River farms as total cultivated acres and total farm investment increased. This inverse relationship between size and farm profits for the Peace River farms may be attributed primarily to below average crop yields in 1967.[1] For the farms studied, the average gross

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[1]Alberta Department of Agriculture, <u>1967 Farm Business Summary, Peace River District of Alberta</u>, Publication No. 819.50-49, 1968 (Edmonton: ADA, 1968).

returns from crops per cultivated acre was only \$15.80. Other conditions that could contribute to the inverse relationship are low livestock prices or high feed costs, thus making some livestock enterprises unprofitable. The overall effect of these adverse conditions was an average operator's return to labour and management of -\$1766, with the smaller farms incurring the smaller losses.

On the thin black farms, profits decreased as size in terms of total farm investment, total man equivalents, and total animal units increased. Again, profits were low, but the exact cause is not evident.

That the adverse conditions mentioned above can influence the group average points out the need for caution when interpreting comparative analysis data on a yearly basis. This is another weakness of comparative analysis that the decision maker must understand if he is to avoid erroneous conclusions. Perhaps standard crop and livestock yields applied to a particular farmer's business would be more meaningful than a group average influenced by highly heterogeneous resources and numerous levels of weather and disease experience.

Prediction Equations

The close relationship that exists in many instances between two factors (independent variables) accounts for the many combinations of variables tried in the search for useful prediction equations. The original plan was to combine explanatory factors having simple correlations among themselves of .20 or less. In

some instances, however, common sense suggested little or no relationship between two factors even though the simple correlation was greater than .20. In such cases the two farm management factors were included in the same equation. From approximately sixty equations constructed, six were selected to illustrate the findings of this research. These are presented in Table 10 for the enterprise stratification and Table 11 for the soil zone stratification.[1]

Combining variables with high correlations in a prediction equation produced multicollinearity and resulted in some variables becoming important when they should not have been significant. The opposite effect also occurred. For example, in equation 1 of Table 10, real estate investment per cultivated acre was significant on livestock farms. This factor was not important, however, when studied in a two variable model. Similar inconsistencies can be found for the stratification by soil zones.

In general it was observed that regression equations are poor predictors of farm profits for the farms stratified according to enterprise. The highest explained variation in farm profits was obtained with equation 2 of Table 10 on grain farms where the multiple coefficient of determination (R^2) was .46.

Higher multiple coefficients of determination were obtained from similar prediction equations applied to the soil zone groups. For example, the variables used in equation 2 of Table 11 on the brown soil group explained 86 percent of the variation in the returns to labour and management. However, this same equation had an $\bar{R}^2$ of

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[1] Multiple standard errors of the estimated dependent variable (Y) are shown in the appendix.

Table 10

LINEAR MULTIPLE REGRESSION EQUATIONS[1] USING FARM MANAGEMENT FACTORS TO PREDICT THE FARM OPERATOR'S RETURN TO LABOUR AND MANAGEMENT BASED ON 1967 ALBERTA FARM BUSINESS ANALYSIS DATA AND STRATIFICATION BY ENTERPRISE

INDEPENDENT VARIABLES	LIVESTOCK FARMS			DIVERSIFIED FARMS			GRAIN FARMS		
	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#
EQUATION 1									
REAL ESTATE INVESTMENT PER CULT. AC.	-24.57	-3.74	.09	-35.40	-3.88*	.07	-40.20	-3.11*	.06
LIVESTOCK INVESTMENT PER CULT. AC.	31.38	1.55	.01	45.89	2.88*	.03	-49.77	-1.25	.01
EQUIPMENT INVESTMENT PER CULT. AC.	7.68	1.22	.01	-76.28	-3.11*	.03	-183.32	-3.59*	.14
CAPITAL RATIO	- .02	-1.35	.01	.02	.36	.00	.02	1.08	.01
GROSS RETURNS FROM CROPS PER CULT. AC.	250.74	4.66*	.10	256.69	6.52*	.16	454.93	7.80*	.19
GROSS RETURNS FROM LIVESTOCK PER A.U.	19.91	4.32*	.17	10.26	1.84	.02	2.07	.46	.00
INTERCEPT TERM	(-7747.35)			(-2628.30)			(-1268.23)		
		R^2 = .39*			R^2 = .31*			R^2 = .41*	
EQUATION 2									
TOTAL ANIMAL UNITS	24.16	3.30*	.11	12.50	1.77	.01	-35.94	-3.23*	.04
TOTAL CULTIVATED ACRES	-2.08	- .88	.01	-4.31	-3.73*	.05	2.60	2.84*	.05
TOTAL EQUIPMENT COSTS PER CULT. AC.	7.55	.60	.00	-582.56	-5.83*	.09	-747.95	-4.15*	.18
CAPITAL RATIO	- .04	-2.85*	.05	- .01	- .10	.00	.01	.54	.00
GROSS RETURNS FROM CROPS PER CULT. AC.	156.90	2.80*	.05	286.75	7.00*	.16	430.41	8.02*	.19
GROSS RETURNS FROM LIVESTOCK PER A.U.	25.33	5.05*	.17	14.27	2.59*	.02	.01	.10	.00
INTERCEPT TERM	(-10223.91)			(-1949.73)			(-4988.61)		
		R^2 = .38*			R^2 = .34*			R^2 = .46*	
EQUATION 3									
GROSS RETURNS FROM CROPS	- .01	.00	.00	.03	.62	.00	.21	4.74*	.24
GROSS RETURNS FROM LIVESTOCK	.19	5.67*	.27	.07	1.33	.04	- .14	-1.62	.03
PERCENTAGE OF CAPITAL IN FIXED ASSETS	-63.73	-1.39	.01	-50.00	-1.90	.02	-66.78	-1.94	.02
EQUIPMENT VARIABLE COSTS PER CULT. AC.	4.77	.22	.00	-261.43	-1.43	.02	-169.31	-0.45	.00
INTERCEPT TERM	(15.95)			(2054.14)			(323.54)		
		R^2 = .29*			R^2 = .08*			R^2 = .29*	

INDEPENDENT VARIABLES	LIVESTOCK FARMS			DIVERSIFIED FARMS			GRAIN FARMS		
	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#
EQUATION 4									
TOTAL PRODUCTIVE MAN-WORK UNITS	2.40	1.14	.01	.26	.14	.00	1.77	.62	.00
EQUIPMENT FIXED COSTS PER CULT. AC.	43.86	1.50	.02	-248.76	-2.06*	.03	-939.25	-3.69*	.11
GROSS RETURNS FROM CROPS PER CROP AC.	219.48	4.18*	.13	160.61	4.99*	.14	257.89	6.39*	.22
GROSS RETURNS FROM LIVESTOCK PER $100 FEED	42.53	4.40*	.16	17.23	2.38*	.03	3.37	.78	.01
INTERCEPT TERM	(-14287.69)			(-6343.33)			(-4453.08)		
		R^2 = .31*			R^2 = .20*			R^2 = .33*	
EQUATION 5									
TOTAL MAN EQUIVALENTS	1520.34	1.46	.02	183.78	.25	.00	372.26	.25	.00
PRODUCTIVE MAN-WORK UNITS PER TOTAL FARM INVESTMENT	179064.73	.57	.00	274368.91	1.69	.01	-163380.30	-0.32	.00
VARIABLE COSTS AS A PERCENTAGE OF TOTAL COSTS	46.56	1.02	.01	-11.93	-0.40	.00	23.02	.44	.01
GROSS RETURNS FROM LIVESTOCK PER $100 FEED	41.63	3.68*	.16	20.62	2.69*	.04	4.68	.87	.01
PRODUCTIVE MAN-WORK UNITS PER MAN EQUIVALENT	5.79	.91	.01	8.09	1.94	.03	8.79	1.12	.02
INTERCEPT TERM	(-14322.00)			(-6920.60)			(-3665.94)		
		R^2 = .20*			R^2 = .09*			R^2 = .04	
EQUATION 6									
TOTAL GROSS RETURNS	.21	6.86*	.31	.14	4.74*	.07	.20	4.82*	.24
EQUIPMENT VARIABLE COSTS PER MAN EQUIVALENT	-2.71	-2.59*	.03	-2.48	-4.58*	.12	-1.43	1.56	.02
PERCENTAGE OF CAPITAL IN FIXED ASSETS	-84.43	-1.91	.02	-44.98	-1.88	.02	-64.52	-1.89	.02
INTERCEPT TERM	(3475.11)			(2837.62)			(1707.45)		
		R^2 = .36*			R^2 = .21*			R^2 = .28*	

1. EQUATIONS OF THE FORM $\hat{Y} = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n$ WHERE β_0 IS THE INTERCEPT TERM AND βn IS THE REGRESSION COEFFICIENT FOR THE RESPECTIVE FARM MANAGEMENT FACTORS (INDEPENDENT VARIABLES).

* SIGNIFICANT AT THE .05 LEVEL OF SIGNIFICANCE.

\# THE CONTRIBUTION BY EACH FACTOR TO THE MULTIPLE COEFFICIENT OF DETERMINATION (R^2). SUMMATION OF THE INDIVIDUAL CONTRIBUTIONS SHOULD EQUAL THE R^2 VALUE. DISCREPANCIES ARE BECAUSE OF ROUNDING NUMBERS TO THE SECOND DECIMAL PLACE.

Table 11

LINEAR MULTIPLE REGRESSION EQUATIONS[1] USING FARM MANAGEMENT FACTORS TO PREOICT THE FARM OPERATOR'S RETURN TO LABOUR ANO MANAGEMENT BASEO ON 1967 ALBERTA FARM BUSINESS ANALYSIS OATA ANO STRATIFICATION BY SOIL ZONE

INDEPENDENT VARIABLES	BROWN			OARK BROWN			BLACK			THIN BLACK			GREY WOOOEO			PEACE RIVER AREA		
	βn	t ratio	#	Bn	t ratio	#	βn	t ratio	#	βn	t ratio	#	Bn	t ratio	#	βn	t ratio	#
EQUATION 1																		
REAL ESTATE INVESTMENT PER CULT. AC.	-58.67	-2.99*	.31	- 21.32	-1.21	.01	-21.07	-2.05*	.04	-23.13	-2.70*	.18	-22.57	-1.45	.01	-65.60	-4.28*	.14
LIVESTOCK INVESTMENT PER CULT. AC.	20.52	.44	.01	31.52	1.01	.02	6.32	.33	.00	- 5.54	-0.20	.00	50.40	1.28	.03	154.17	5.49*	.11
EQUIPMENT INVESTMENT PER CULT. AC.	43.04	.46	.01	- 143.42	-1.62	.05	9.37	1.71	.02	-37.25	- .69	.01	-70.46	-1.92	.02	-132.09	-3.22*	.11
CAPITAL RATIO	- 2.03	- .17	.00	.01	.26	.00	.03	1.08	.01	- .01	-0.71	.01	- .01	- .24	.00	- 1.67	-2.04*	.04
GROSS RETURNS FROM CROPS PER CULT. AC.	123.37	1.70	.24	417.01	4.16*	.20	348.77	6.28*	.27	156.84	1.38	.02	328.36	4.63*	.27	411.91	6.42*	.17
GROSS RETURNS FROM LIVESTOCK PER A.U.	-28.76	-1.33	.06	4.23	.50	.00	17.77	3.76*	.07	25.91	3.11*	.14	11.84	1.43	.04	- 3.06	-1.05	.01
INTERCEPT TERM	(6233.82)			(-4494.43)			(-9934.42)			(-3874.51)			(-4988.20)			(-295.68)		
		R^2 = .63*			R^2 = .28*			R^2 = .40*			R^2=.36*			R^2 = .38*			R^2 = .58*	
EQUATION 2																		
TOTAL ANIMAL UNITS	7.15	.75	.01	-10.68	-0.87	.01	23.18	3.89*	.11	-10.19	-1.35	.04	15.57	1.89	.14	11.69	.92	.01
TOTAL CULTIVATEO ACRES	4.34	5.53*	.38	- .86	-0.42	.00	2.63	1.61	.01	- 4.45	-1.77	.04	4.69	2.20*	.05	- 9.20	-6.99*	.39
TOTAL EQUIPMENT COSTS PER CULT. AC.	-447.48	-3.04*	.12	- 639.87	-1.68	.04	16.95	1.72	.01	-807.23	-3.69*	.10	-348.61	-2.64*	.03	-315.56	-2.41*	.94
CAPITAL RATIO	5.00	.69	.01	.01	.02	.00	.03	1.35	.01	- .01	-0.82	.01	- .01	.00	.00	- .95	-1.19	.01
GROSS RETURNS FROM CROPS PER CULT. AC.	210.49	4.80*	.30	420.13	3.88*	.20	264.74	5.00*	.27	271.66	2.39*	.06	281.73	4.21*	.27	316.10	5.42*	.18
GROSS RETURNS FROM LIVESTOCK PER A.U.	27.65	1.96	.06	6.71	.77	.01	17.61	4.26*	.10	32.80	4.12*	.15	22.14	3.21*	.07	- .90	- .36	.00
INTERCEPT TERM	(-6543.04)			(-3235.52)			(-13617.90)			(-736.36)			(-8300.20)			(1412.28)		
		R^2 = .86*			R^2 = .27*			R^2 = .51*			R^2 = 40*			R^2 = .56*			R^2 = .63*	
EQUATION 3																		
GROSS RETURNS FROM CROPS	.23	4.37*	.57	.14	2.33*	.09	.18	3.47*	.06	- .09	-1.00	.01	.24	4.13*	.36	- .08	-0.85	.02
GROSS RETURNS FROM LIVESTOCK	.01	.00	.00	.02	.24	.00	.13	4.44*	.40	.03	.47	.00	.19	3.04*	.13	.03	.30	.00
PERCENTAGE OF CAPITAL IN FIXED ASSETS	-119.95	-1.66	.08	-38.54	-0.75	.01	-51.14	-1.68	.01	-132.77	-2.24*	.09	-22.81	-0.48	.00	16.95	.39	.00
EQUIPMENT VARIABLE COSTS PER CULT. AC.	80.48	.32	.00	516.52	.85	.01	12.79	.80	.00	-1158.41	-2.32*	.07	-85.93	- .35	.00	548.63	1.53	.08
INTERCEPT TERM	(3345.06)			(-3304.81)			(-1292.62)			(12598.96)			(-2351.31)			(-3837.54)		
		R^2 = .65*			R^2 = .11			R^2 = .47*			R^2 = .18*			R^2 = .50*			R^2 = .10	

Table 11 (continued)

INDEPENDENT VARIABLES	BROWN			DARK BROWN			BLACK			THIN BLACK			GREY WOODED			PEACE RIVER AREA		
	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#	βn	t ratio	#
EQUATION 4																		
TOTAL PRODUCTIVE MAN-WORK UNITS	14.30	4.05*	.31	4.69	1.37	.04	8.83	4.65*	.26	-4.46	-1.76	.05	10.94	4.63*	.36	-2.22	-0.58	.00
EQUIPMENT FIXED COSTS PER CULT. AC.	-845.18	-2.57*	.13	-504.94	-1.20	.02	51.96	2.44*	.03	-412.92	-1.45	.03	-503.76	-3.27*	.06	-820.91	-2.99	.08
GROSS RETURNS FROM CROPS PER CROP AC.	239.66	3.92*	.23	233.99	3.92*	.16	279.64	6.41*	.14	125.83	1.44	.03	264.23	4.50*	.09	277.14	4.18*	.11
GROSS RETURNS FROM LIVESTOCK PER $100 FEED	11.86	1.39	.05	7.70	1.17	.02	35.60	4.34*	.08	42.76	3.28	.12	20.33	2.49*	.06	13.57	2.51	.08
INTERCEPT TERM	(-10332.79)			(-8738.64)			(-18082.09)			(-7080.51)			(-9850.59)			(-3877.78)		
		R^2 = .72*			R^2 = .24*			R^2 = .51*			R^2 = .23*			R^2 = .57*			R^2 = .27*	
EQUATION 5																		
TOTAL MAN EQUIVALENTS	2259.11	.96	.16	-1583.75	-.96	.02	1221.48	1.63	.02	-5951.33	-4.13*	.15	3345.64	3.09*	.32	-5316.51	-3.62*	.10
PRODUCTIVE MAN-WORK UNITS PER TOTAL FARM INVESTMENT	1470622.51	1.38	.04	738406.64	1.62	.03	278109.09	1.03	.01	640413.98	2.81*	.07	143213.04	.60	.00	1114041.54	6.79*	.22
VARIABLE COSTS AS A PERCENTAGE OF TOTAL COSTS	-150.61	-1.22	.08	-23.51	- .14	.00	-9.28	-.26	.00	-5.84	- .10	.00	33.35	.79	.01	20.76	.51	.00
GROSS RETURNS FROM LIVESTOCK PER $100 FEED	-9.28	-..58	.02	5.84	.90	.01	35.52	3.91	.12	29.34	2.43*	.12	11.68	1.22	.04	2.99	.69	.01
GROSS RETURNS FROM CROPS PER CULT. AC.	81.66	1.34	.07	400.69	4.14*	.20	321.75	5.97	.27	257.32	2.32*	.06	217.29	3.12*	.10	331.66	5.80*	.28
INTERCEPT TERM	(-340.13)			(-8391.18)			(-16039.28)			(-7772.96)			(-13379.53)			(6436.25)		
		R^2 = .37*			R^2 = .26*			R^2 = .42*			R^2 = .41*			R^2 = .46*			R^2 = .61*	
EQUATION 6																		
TOTAL GROSS RETURNS	.23	4.03*	.51	.18	3.33*	.17	.25	10.27	.52	.03	.51	.00	.35	10.59*	.60	.13	1.40	.03
PERCENTAGE OF CAPITAL IN FIXED ASSETS	-86.33	-1.11	.07	-39.61	- .81	.01	-45.11	-1.59	.01	-133.43	-2.21*	.09	-33.29	-1.04	.01	-11.77	-0.28	.00
EQUIPMENT VARIABLE COSTS PER MAN EQUIVALENT	-1.23	-0.75	.02	-0.91	-.77	.01	-1.45	-1.84	.01	-1.79	-1.37	.03	-3.17	-5.10*	.14	-2.00	-2.30*	.06
INTERCEPT TERM	(2835.38)			(-1478.95)			(-396.56)			(8795.46)			(567.42)			(288.71)		
		R^2 = .60*			R^2 = .19*			R^2 = .54*			R^2 = .12*			R^2 = .75*			R^2 = .09	

[1]EQUATIONS OF THE FORM $\hat{Y} = \beta_0 + \beta_1 X_1$ ---+$\beta_n X_n$ WHERE β_0 IS THE INTERCEPT TERM AND β_n IS THE REGRESSION COEFFICIENT FOR THE RESPECTIVE FARM MANAGEMENT FACTORS (INDEPNDENT VARIABLES).

*SIGNIFICANT AT THE .05 LEVEL OF SIGNIFICANCE.

#THE CONTRIBUTION BY EACH FACTOR TO THE MULTIPLE COEFFICIENT OF DETERMINATION (R^2). SUMMATION OF THE INDIVIDUAL CONTRIBUTIONS SHOULD EQUAL THE R^2 VALUE. DISCREPANCIES ARE BECAUSE OF ROUNDING NUMBERS TO THE SECOND DECIMAL POINT.

only .27 on farms from the dark brown group.

The results of this study point out weaknesses of comparative analysis in addition to the shortcomings outlined in Chapter Three. These weaknesses are associated with data variability and stratification of the farms. Also, the significant farm management factors are not well integrated with economic theory of the firm. Therefore, the theoretical models cannot be used efficiently in the decision making process.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

Results of this study show that a number of the traditional farm management efficiency factors are of no help to the farm manager. This is demonstrated by the large amount of analysis that yielded inconclusive and contradictory results. The importance of many other factors appears questionable. The farm management factors that did appear to have a reasonably consistent and significant influence on the operator's return to labour and management for all stratifications were:

1. Measures of size
2. Capital turnover
3. Gross returns per man equivalent
4. Percentage of capital in fixed assets (negative relationships)
5. Gross returns from crops per cultivated acre
6. Gross returns from livestock per animal unit
7. Gross returns from livestock per $100 feed
8. The success index.

The failure of many other factors to be consistent indicators of farm profits is attributed to the extreme data variability. As outlined in Chapter Six, this variability could be the result of differences in asset evaluations, location and demand for land, losses from weather, disease, or insects, accounting errors, or the heterogeneous nature of farm resources. Heterogeneity results from

widely varying enterprise combinations, resource qualities and combinations, and production processes. This makes the use of a group average highly questionable and largely unrelated to the conditions for profit maximization stipulated by the economic theory outlined in Chapter Three.

Total gross returns was found to be the best measure of size. As shown in Table 8, the significance of other measures of size depended on the group. For example, total productive man-work units was important on livestock farms, but not on diversified or grain farms.

Because capital turnover is dependent on many of the same factors affecting the return to labour and mangement, problems of multicollinearity arose when it was included as an explanatory variable. For this reason it was not used in any of the regression equations presented in Tables 10 and 11. It was, however, used as an independent variable (X) in the two variable model to check its level of significance and correlation with the operator's return to labour and management. With capital turnover being related to the residual profit measure (simple correlations of -.47 to -.70 depending on the group), the significance of this factor for all groups was expected. It is, therefore, of minimal value in comparative analysis unless used as an indicator of success, rather than of operator's labour earnings.

The crop and livestock productivity factors shown above were important depending on the type of predominant enterprise in

the stratum. Gross returns from livestock per animal unit was important in the black soil zone, where livestock and diversified farms comprised 40 and 44 percent respectively of the total farms.

Stratification is very important because of the heterogeneous nature of the farms studied. Neither the enterprise nor soil zone groupings used in this study was adequate. Results suggest that the farms must be stratified by at least the general enterprise type (livestock, diversified, or grain) within the same soil zone. Additional research is required, however, to determine the adequacy of this stratification method. It may be necessary to stratify farms according to each type of enterprise; for example, dairy enterprises within a whole or split soil zone.

Although the success index explained a surprisingly low percentage of variation in the operator's return to labour and management for most strata, it should be further studied. It was hoped that such an index would privde a meaningful basis for comparison and thereby a systematic procedure for farm business analysis. Because the success index consists of a margin times volume concept in its calculation (as outlined on page 91), this index should be a strong indicator of profits being made on the individual farm. A low success index could indicate three possible weaknesses in the farm business: (1) low total gross returns relative to resources used; (2) variable costs not wisely expended; or (3) total farm investment too high relative to potential output. This provides the opportunity for a systematic net work analysis and location of weaknesses in resource allocation.

If economies of size[1] exist on the sample farms studied, then some of the farm management factors may have a curvilinear (nonlinear) relationship with farm profits. This was checked by means of a logarithmic model of the form, $\text{Log } Y = \text{Log } \beta_0 + \beta_1 \text{Log } X_1 + \cdots + \beta n \text{ Log } Xn$. Although there were indications that non-linear relationships with the operator's return to labour and management did exist, time did not permit full exploration of this problem. Therefore, additional research is required to determine which farm management factors have a curvilinear relationship with farm profits.

Conclusions

Existing comparative analysis methods analyzed in this study appear in themselves to have minimal value as a tool for decision making in farm planning. They take a deductive approach to problem solving, in that group averages are used to assess a particular farmer's weakness or strength in relation to certain efficiency measures deemed important. Not only are the group averages of questionable meaning because of the heterogeneous composition of farms included in their calculation, but there is no assurance that they represent optimal levels for profit maximization.

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[1]Economies of size means reductions in total cost per unit of production resulting from changes in the quantity of resources employed by the firm, or in the firm's output.

Group averages are means of frequency distributions with wide ranges between high and low farms (see Figure 14). Thus standard deviations are high, and distributions are frequently not normal, but skewed either to the right or to the left. Even if it were assumed that some farmers in the group were operating at optimal levels, it would be only by chance that the group average would represent a meaningful bench mark for profit maximization. Inasmuch as the group average value for an efficiency measure is a mean of a wide frequency distribution, it is obvious that it will invariably underestimate standards required for maximum profitability. Thus comparative analysis is not an adequate guide for the aggressive entrepreneur, and he should probably head for the upper limits of the frequency distribution making up a particular group average.

Some analysts have recognized this problem and, consequently, have introduced a rule of thumb calling for standards of efficiency at least one-third above mean values. However, this does not correct the inherent weakness of comparative analysis, which operates on the underlying assumption that group averages are adequate indicators for an individual farm with its unique set of resources, conditions, and constraints.

It is suggested that economic theory and profit maximization models are necessary as an additional set of guidelines for the farm operator. This implies that the farm manager can spend his time more productively by using economic principles as guides than by comparing his operation with group averages of questionable origin.

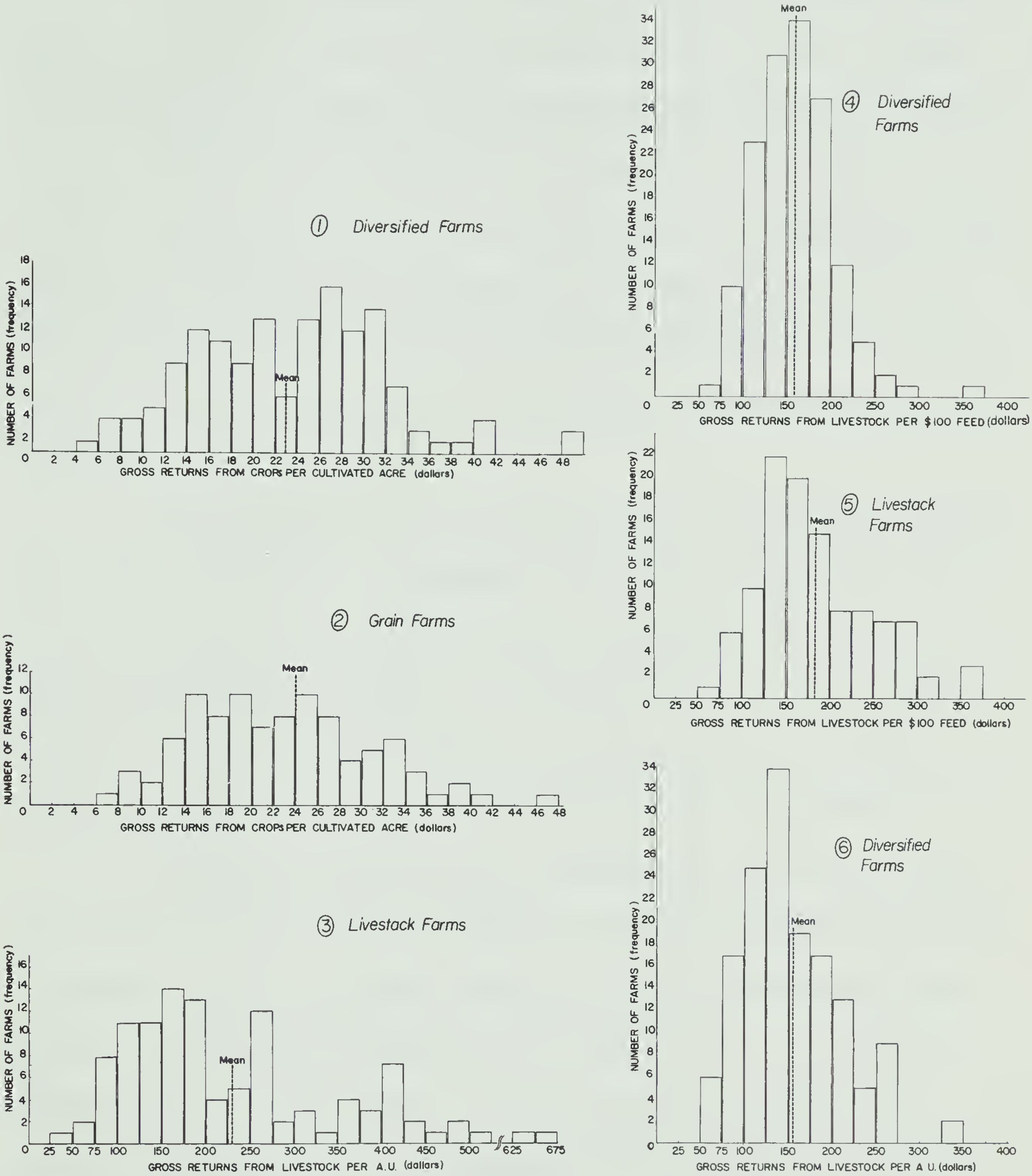

Figure 14

FREQUENCY DISTRIBUTIONS

Given the synthesis of farm firm theory into models that can be utilized for decision making over the past several decades, it is realistic to suggest that comparative analysis, which originated near the turn of this century, be delegated a more minor role as a tool in farm business analysis and planning. More emphasis should be placed on teaching farm management principles to analysts and farm managers so that they can better interpret farm records using marginal analysis and concepts of production function and cost curve analysis.

The practical tool for such analysis is the partial budget or linear programming. The emphasis will shift to research results and past records on the same farm and away from cross-sectional analysis using group averages. In other words, the modern farm manager can make better decisions by relying more on reasoning through economic models than on comparison with his neighbours.

Comparative analysis can, nonetheless, be a useful guide for uncovering major maladjustments in the farm organization and in management. It is suggested, however, that refined analysis can only be accomplished by increasing the emphasis on the relevant economic theory of the firm. In order to utilize comparative analysis more effectively, a thorough review of present techniques should be undertaken. In such a review, problems of stratification, heterogeneity of conditions and resources, accuracy of measurement, and relation to economic theory should be considered.

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APPENDIX

Table 12

MULTIPLE STANDARD ERRORS OF ESTIMATE FOR THE PREDICTION EQUATIONS IN TABLE 10 ON THE FARMS STRATIFIED BY ENTERPRISE[1]

Equation	Livestock	Diversified	Grain
1	$ 5836	$ 3606	$ 4524
2	5876	3513	4310
3	6212	4114	4924
4	6149	3854	4764
5	6650	4104	5745
6	5885	3813	4922

[1] The multiple standard error of estimate measures the deviations of the actual Y values from the predicted values ($\hat{Y}$).

Table 13

MULTIPLE STANDARD ERRORS OF ESTIMATE FROM
THE PREDICTION EQUATIONS IN TABLE 11 ON THE
FARMS STRATIFIED BY ENTERPRISE[1]

Equation	Brown	Dark Brown	Black	Thin Black	Grey Wooded	Peace River
1	$ 3831	$ 5526	$ 4874	$ 6067	$ 3696	$ 2390
2	2323	5585	4409	5861	3066	2242
3	3221	6016	4509	6733	3236	3434
4	3024	5556	4348	6521	2990	3079
5	4724	5543	4770	5766	3385	2290
6	3433	5697	4198	6896	2277	3413

[1] The multiple standard error of estimate measures the deviations of the actual Y values from the predicted values ($\hat{Y}$).